A METHODOLOGY FOR LONG-TERM FORECASTS OF AIR FORCE PILOT RETENTION RATES: A MANAGEMENT PERSPECTIVE

THESIS

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The opinions and conclusions in this paper are those of the author and are not intended to represent the official position of the DOD, USAF, or any other government agency.

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Preface

This study culminated in the production of several models that may be of use to Air Force Leadership in tackling the pilot retention problem. During the course of this research, it became evident that merely providing the models would be of little value if they were not presented in some sort of management context. I therefore presented the modeling effort as a portion of the turnover management process.

It also became evident that the long-term retention problem is likely to get worse. This is due to several reasons: airline expansion, pilot retirements, population demographics, and some of the attempts to control turnover themselves. I believe the latter two are time bombs that must be dealt with now, before their impact is felt.

Any thesis is a synergistic effort and I will therefore not attempt to single out every individual who assisted me with this research. I hope that a simple "thank you" to the Institute's faculty and staff will suffice. I would be remiss, however, if I did not thank my wife, Jeanette, and our children, Brian, John, Mary, Peter, and Thomas for their patience and understanding. I know the time lost cannot be made up, but hopefully we will all be better for the experience. Thanks also, to Mom and Dad.

I hope these models may be of some use. If you have any questions, you can find me on the golf course.

Bruce A. Guzowski

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Abstract

Personnel planners in various Air Force agencies use models, among other things, to aid them in forecasting pilot retention rates. This Thesis ~~research ef~~fort attempted to forecast retention rates three years ahead with the use of multiple regression analysis techniques. Such models can be of use to Air Force leaders to develop proactive policies and programs to combat poor retention forecasts.

Economically quantifiable variables were primarily used in the modeling effort. However, some year groups could not be adequately explained with the use of economic variables alone. The models for year groups eight, twelve, and thirteen used the retention rates of "peer groups" to assist in explaining their own retention rates.

All models were subjected to common internal tests associated with linear regression. External validity was verified by the use of a withheld data set. Forecasts were made for Fiscal Years 90, 91, and 92, using independent variable data from 1987, 1988, and 1989, respectively. All tests and forecasts were thoroughly documented.

The practical and policy implications of these forecasts were discussed, and some thoughts about possible policies and programs to increase retention were advanced. Improvements to further the utility of these models were suggested.

A METHODOLOGY FOR LONG-TERM FORECASTS OF AIR FORCE PILOT RETENTION RATES: A MANAGEMENT PERSPECTIVE

I. *Introduction*

General Issue

Employee turnover in any organization can be very costly if not controlled. In the Air Force, the loss of a single pilot to the civilian sector represents a cost of millions of dollars in training and experience (11:11). Additionally, if large numbers of combat-capable pilots depart the service before they are eligible for retirement, a potential exists for a pilot shortage within the Air Force, where there are not enough pilots to perform the jobs which require a pilot's presence (flying or staff duty). Such a shortage could quickly translate into lost war-fighting capability.

A 1984 Air War College Research Report discussed the consequences of pilot shortages under manning policies in place at that time. The report noted that previous pilot shortages were solved by drawing on the surplus of pilots within the rated supplement program (a program that assigns rated officers [pilots and navigators] to non-flying positions). Thus, a surplus of rated officer experience was maintained during periods when pilot retention was high, and this "reserve" was drawn upon to fill vacancies created when retention rates fell below levels required to maintain combat readiness. However, current pilot losses are greater than what the rated supplement program can support. While Air Force policy is geared toward retaining those pilots already on active duty, vacancies created by turnover within this group are, for the first time in Air Force history, being filled by younger, less experienced officers (13:20). Indeed, as turnover becomes ever larger, the effect of filling vacancies from below will inevitably drive the high standard of readiness the Air Force has traditionally maintained to some lower level (13:19).

It should be noted that all turnover does not bear bitter fruit. Indeed, the Air Force recognizes this, and has historically planned for a cumulative retention rate of pilots within the six to eleven year group of sixty percent. In other words, for every ten pilots entering their seventh year of active duty, the Air Force plans on having six of those pilots on active duty by the end of their eleventh year of service. This translates to roughly a ten percent turnover rate per year, which is comparable to the rates that civilian firms plan for (28). This planned turnover rate is *functional* turnover, where the health of the organization is not jeopardized by these "programmed" losses. However, turnover rates in excess of those planned, are *dysfunctional* and need to be corrected if the organization is to remain healthy and viable.

Turnover Research

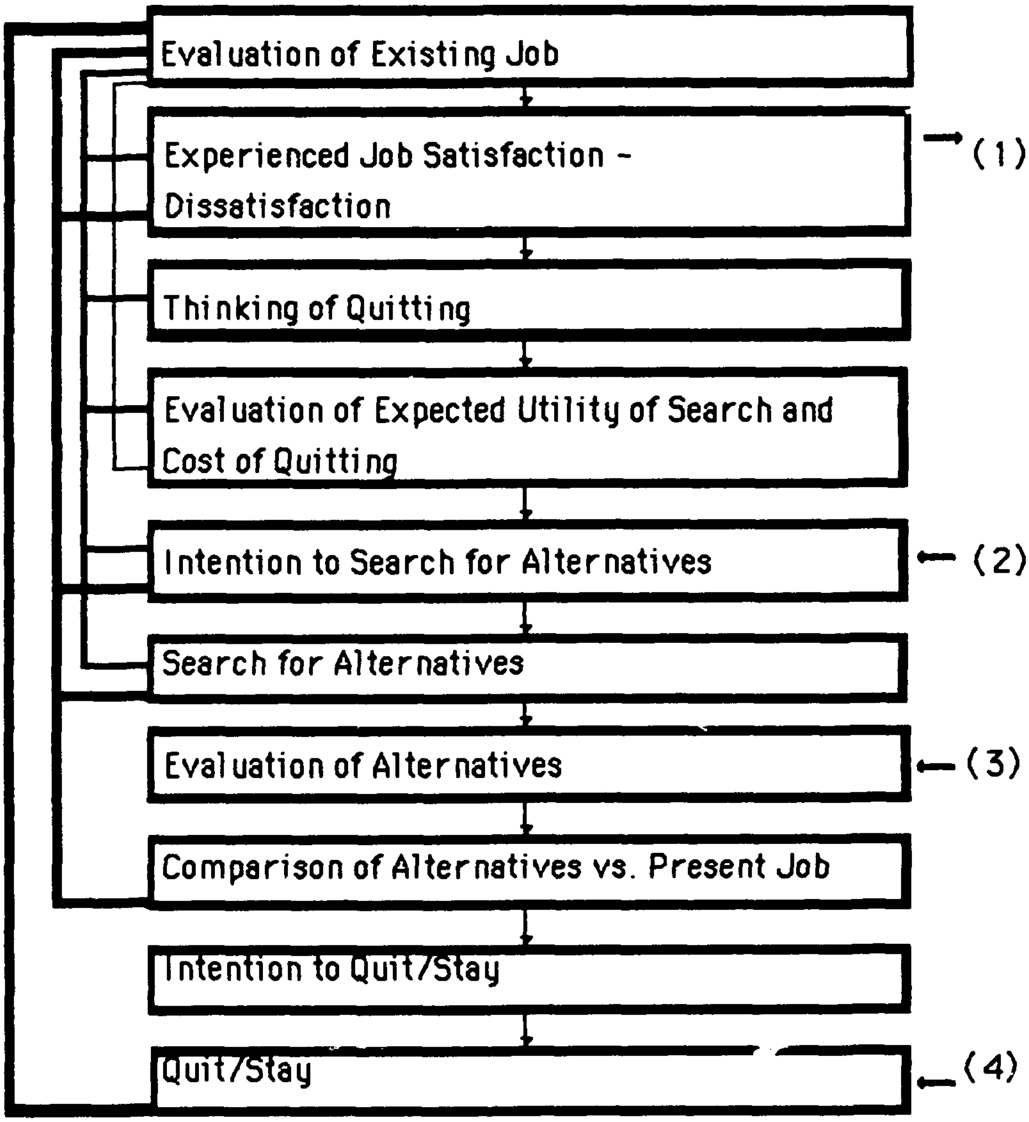
There have been over 1000 studies of employee turnover during this century (18:82). In 1977, William H. Mobley produced his *Intermediate Linkages Model* of employee turnover (Figure 1), which focused on turnover as a process. In Mobley's research, the intention to quit was deemed to be the only reliable predictor of the turnover event (18:122). His research has become the foundation of modern studies on employee turnover (28). Mobley asserts that employee turnover *is* manageable in a *dynamic* environment:

> The manager must be able to: ***diagnose*** the nature and probable determinants of turnover in his organization; ***assess*** the probable individual and organizational consequences of the various types of turnover; ***design and implement*** policies, practices, and programs for effectively dealing with turnover; ***evaluate*** the effectiveness of changes; and ***anticipate*** further changes to effectively manage turnover....(18:78)

Mobley offers a graphic portrayal of the management view of this turnover process (Figure 2).

A Systems Approach

General systems theory says that an organization may be viewed as a system that interacts with its environment in an analogous manner to biological systems:



Notes:

(1) Alternative forms of withdrawal, e.g., absenteeism, passive job behavior

(2) Non-job related factors, e.g., transfer of spouse, may stimulate intention to search

(3) Unsolicited or highly visible alternatives may stimulate evaluation

(4) Impulsive behavior

Figure 1. Mobley's Intermediate Linkages Model (18:123)

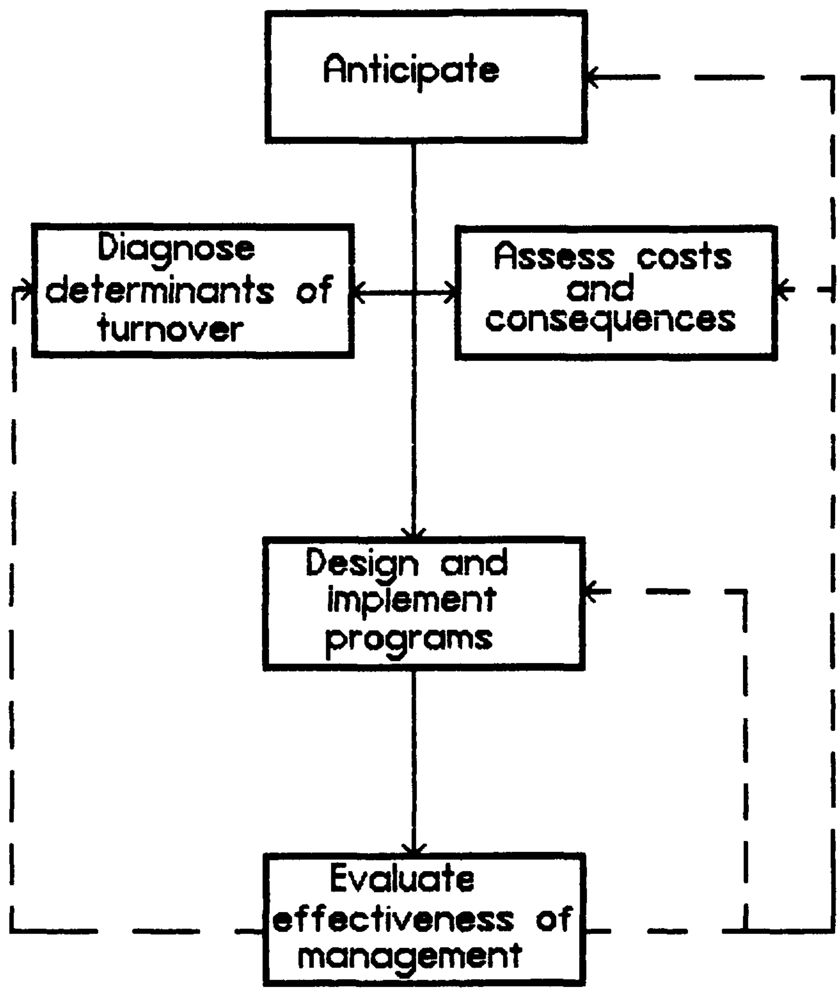


Figure 2. Management Perspective of the Turnover Process (18:12)

> . . . Richard Johnson, Fremon Kast, and James Rosenzweig related the corporate enterprise structure . . . to an open-ended cell:
>
> An organism is an open system which maintains a constant state while matter and energy which enter it keep changing (so-called dynamic equilibrium). The organization is influenced by, and influences, its environment. Such a description of a system adequately fits the typical business organization. The business organization is a man-made system which has dynamic interplay with its environment -- customers, competitors, labor organizations, suppliers, government and many other agencies. Furthermore, the business organization is a system of interrelated parts [subsystems] working in conjunction with each other in order to accomplish a number of goals, both those of the organization and those of the individual participants. (15:66)

Any system or subsystem takes *inputs,* processes them (*throughput*), and produces *outputs* (5). Figure 3.a. is a simple depiction of this *systems* model. The vertical arrows in and out of the *throughput* box represent interaction with the environment in which the system exists.

Figure 3.b. is an attempt to model the Air Force personnel system with respect to systems theory. Here, *inputs* may be viewed as recruits. The *throughput* box may in turn be seen as Mobley's turnover process (Figure 1). Note here that interaction with the environment is depicted as being one way (out). This is intended to show that once pilot turnover occurs (vertical arrows), replacement currently comes only from within, through more *inputs.* *Outputs* may be viewed in this second model as functional turnover and retirement.

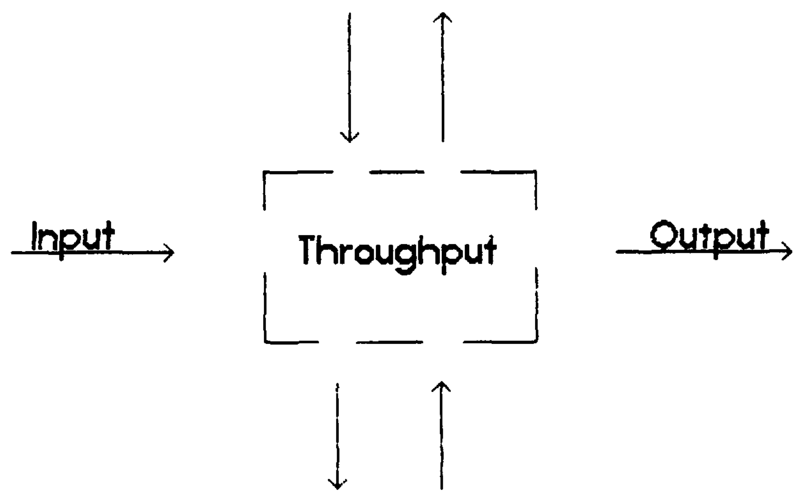


Figure 3.a. Simple Systems Model

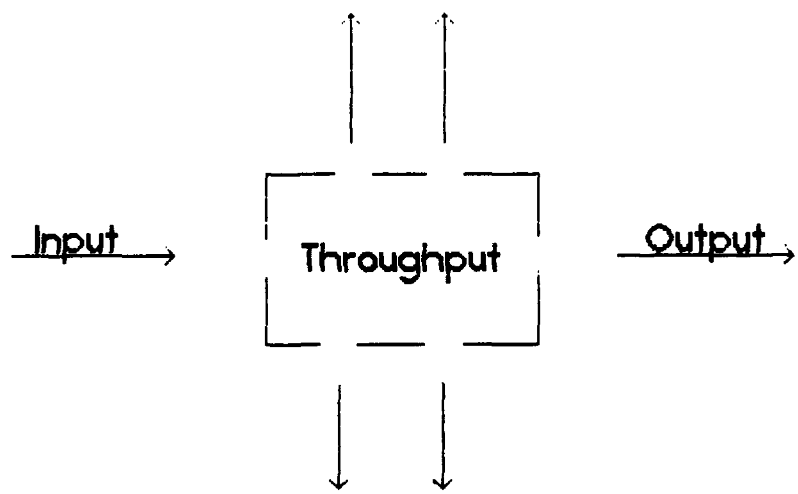


Figure 3.b. Modified Systems Model

Systems that freely interact with the environment are known as open systems, while those that do not are called closed systems. Since any organizational system is inherently open, it thus becomes useful to view its degree of openness. Organizational systems may therefore be seen as relatively open or relatively closed (17:65). The model in Figure 3.b. may be seen as a relatively closed system. Tom Peters, in his book, *Thriving on Chaos*, offers this view of the interaction open systems must have with their environments:

> The winners of tomorrow will deal *proactively* with chaos, will look at the chaos per se as the source of . . . advantage, not as a problem to be got around. Chaos and uncertainty are . . . opportunities for the wise (23:xiv).

When a system chooses to limit interaction with its environment, it "buys" short term stability at the expense of long term stability (5), (17:66). The limited interaction with the environment depicted in the second model may then be seen as a source of long term instability. An organization's limited interaction with its environment may manifest itself in the form of controls or regulations, often not producing the desired results. Peter Drucker, in *The New Realities,* states:

> . . . The Chicago economist George J. Stigler (winner of the 1982 Nobel prize in Economics) has shown in years of painstaking research that not one of the regulations through which the U.S. Government has tried over the years to control, direct, or regulate the economy has worked. They were either ineffectual or produced the opposite of the intended results. (6:166)

USAF Pilot Turnover

Mobley has identified four general classes of turnover determinants:

> ***external economy***: unemployment, inflation, etc.
> ***organizational variables***: e.g., reward system, job design, leadership
> ***individual non-work variables***: e.g.,spouse's career, family responsibility
> ***individual work related variables***: e.g., values, expectations, commitment (18:78)

Concentrating on any single one of these determinants will not give the Air Force leader a complete picture of the turnover process within his organization. However, a significant positive correlation has been found to exist between pilot turnover and domestic airline pilot hiring activity. This hiring activity has in turn been shown to be positively correlated to general economic strength (8:15). These positive correlations have been the basis of some models used by Air Force planners to forecast pilot turnover (25:14).

The View of Management.

Air Force leadership has been following Mobley's paradigm for turnover management. Attempts are made to anticipate turnover and its determinants are assessed through various studies and surveys. The costs and consequences of pilot turnover are subsequently calculated, and policies and programs are then implemented which address the negative effects of pilot turnover.

As pilot turnover in recent years has become dysfunctional within the Air Force, several remedial measures have been implemented by Air Force leaders to address suspected turnover variables. These efforts have been primarily directed at the *organizational variables* determinant, since Mobley's other classes of determinants are less easily influenced by leaders. Turnover may be seen as a measure of employee morale (28). When morale (and hence satisfaction) is high, turnover is low. The converse is also true. One method by which Air Force leadership has attempted to address the perceived morale problem is through giving the pilot a distinct identity. The Air Force of the 1950s had nearly 60,000 pilots. Today, there are roughly one-third that number on active duty (13:9). Indeed, in today's Air Force, officers that are pilots are in the minority. The issuance of leather flight jackets to aircrews was reinstituted in part to combat the problem of pilots failing to identify themselves with the Air Force, and to therefore increase their *esprit de corps*, or morale.

Another organizational variable addressed by Air Force leadership is the reward system (compensation) for pilots. Beginning in January of 1989, a pilot who had completed the initial active duty service commitment (ADSC) incurred from Undergraduate Pilot Training (UPT), with less than 14 years of total service, was eligible to receive a bonus payment of up to $12,000 per year. In return for the these payments, the pilot obligated himself to serve through the 14-year point of total service.

A compensation measure more recently enacted by Congress increased the monthly payments pilots (and navigators) receive under the Aviation Career Incentive Pay (ACIP) act. Otherwise known as "flight pay," these payments have been raised to a maximum of $650 per month.

According to Mobley, once such policies and programs are implemented, their effectiveness must be evaluated. While it is not the author's intent to judge the effectiveness of the aforementioned programs, voluntary retention rates have not been significantly positively affected by these measures, though the decline in retention rates appears to be leveling off (9:9).

The key to Mobley's management perspective of the turnover process lies in management's ability to anticipate the turnover event. Theoretically, if an event is anticipated far enough in advance of the time that it occurs, measures may be taken by management to either rectify the determinant causes of the event, and hence alter the outcome, or act to mitigate the consequences of the event if it indeed occurs. Thus, the previously discussed initiatives taken by Air Force leaders may be seen as being directed at eliminating the causes of turnover.

However, all causes of turnover are not under the control of the Air Force leader. The strong positive correlation between airline hiring and pilot turnover is but one example: the Air Force leader has no ability to control airline hiring. As airlines continue to raid the Air Force's "bank" of trained pilot resources (and it appears they wish to continue to do so for the coming decade [30:S10; 22:101]), another policy has been implemented by Air Force leadership in an attempt to deny these resources from the competition: lengthen active duty service commitments (ADSCs) incurred by those graduating from UPT.

Figure 4 plots ADSCs incurred by pilots. The ADSC for UPT has gone from six years for a pilot graduating in 1980 to 10 years for one who graduates today (10:7). Clearly, increasing ADSCs incurred from UPT is a very effective method for maintaining the desired number of pilots within the Air Force. Such policies, though, may not be fully evaluated until these pilots are eligible to leave the service. Thus, the impact of a 10-year ADSC for pilots graduating from UPT in 1990 will not be known until the year 2000.

Anticipating USAF Pilot Turnover.

In 1987, an Air Force Institute of Technology (AFIT) graduate student, Captain James R. Simpson, conducted research on the revision of the *Econometric Adjustment Model*, which is one model used by Air Force planners to forecast pilot retention rates. The result of his research

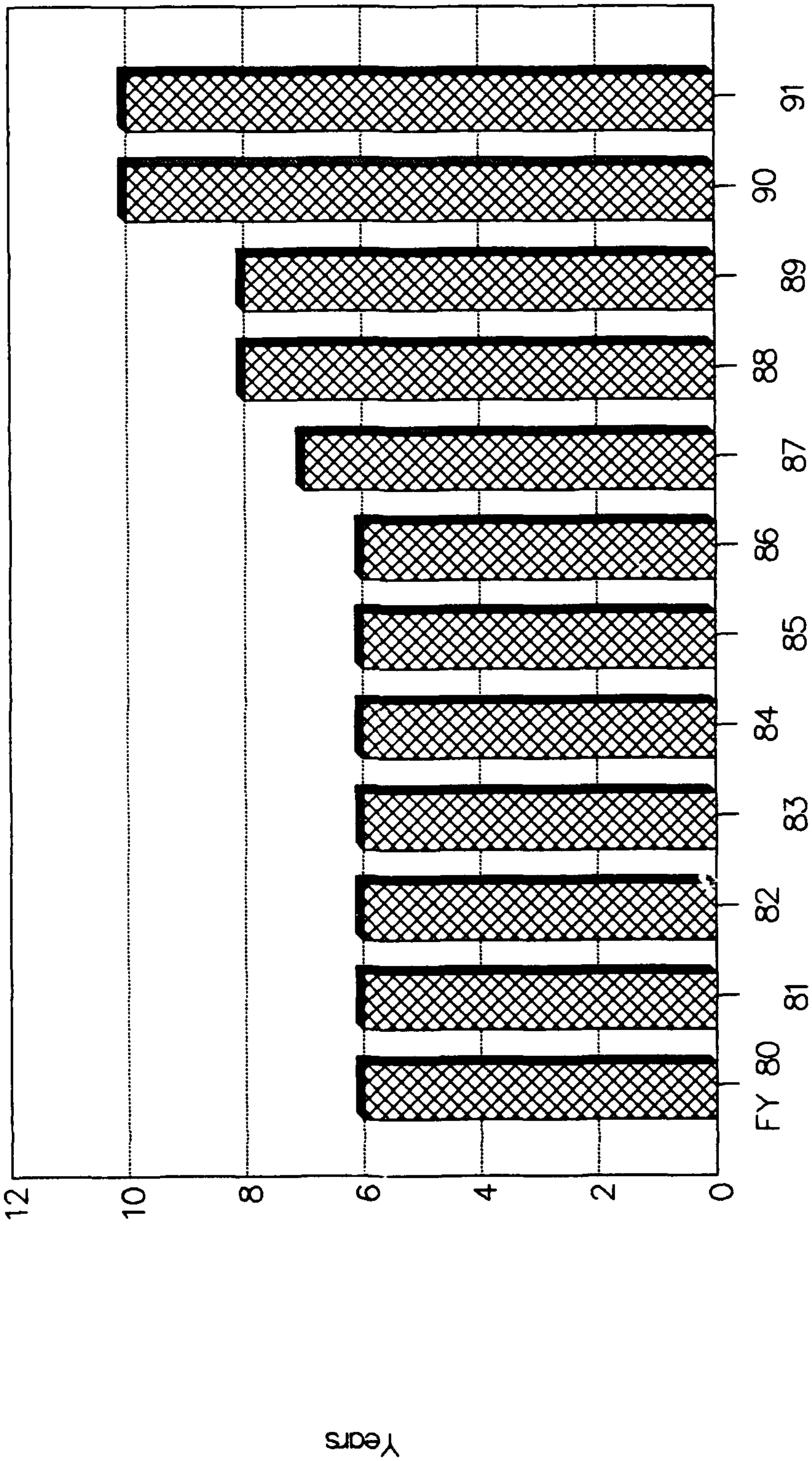


Figure 4. ADSCs Incurred from UPT

was a *Pay Model*, which used regression analysis techniques to forecast pilot retention rates by one year.

Econometrics.

"Econometrics is the art and science of using statistical methods for the measurement of economic relations" (3:1). An econometric model is one that generally uses regression analysis methods to forecast future values of a desired event (24:1). The event of interest in this research is USAF voluntary pilot retention rates. Voluntary retention rates are calculated by subtracting the number of non-retirement eligible pilots who leave the Air Force each fiscal year (FY), by year group, from the number of pilots in the same year group, who are eligible for at least one day during the same FY, to leave the service. This number is in turn divided by the eligible population to provide the retention rate.

An econometric model employs what is known as the *causal* method of forecasting, where some economic events are shown to cause other economic events. For example, a simple econometric model would be one that links unemployment levels to claims for unemployment insurance payments (a rise in the unemployment rate would cause a rise in the number of claims for unemployment compensation). Econometric models that use regression analysis are capable of producing valid long-term (2 to 5 years) forecasts (31:38).

In his recommendations for further research, Captain Simpson stated:

> . . . enhancements to this model that would increase its utility include the following: . . . predict retention rates in the out years (2 or more years ahead) . . . .(25:55)

Specific Problem

The Pay Model developed by Captain Simpson adequately predicted turnover rates of Air Force pilots in year groups 7, 8, 9, 10, and 11. However, the short lead times it provided did not give Air Force planners enough warning of significant movements in pilot retention rates. To assist Air Force planners in the vital area of rated personnel management, a model that can provide accurate retention predictions with at least two years lead time is needed.

Research Objective

Captain Simpson's research showed that regression analysis was a valid technique to predict Air Force pilot turnover. Yet, the computer program he developed provided only twelve-month lead times. The objective of this research is to develop a regression model that will adequately predict pilot retention three years in advance.

Scope

For the purpose of this research, the population of concern will be those Air Force pilots who have completed a minimum of seven but not more than 14 years of service (YOS) in the USAF. These year groups comprise the target year groups of current Air Force pilot retention efforts, as evidenced by the policies and programs mentioned in this chapter.

II. *The Retention Model*

Introduction

An econometric model that attempts to predict future values of some dependent variable is known as a forecast. Econometric forecasting uses independent variables (IVs), generally in a regression equation, to predict future values of a dependent variable (DV). These IVs are said to display causality of the DV. In other words, each IV should have some predictability of the DV (12:195).

As previously stated, general economic strength is an accurate predictor of airline hiring, and in turn, pilot turnover. It must therefore be determined which variables may be able to predict economic strength or airline hiring three years hence. Such variables are known as leading indicators, and their use in regression analysis forecasting is highly desirable (1:122). A leading indicator displays what is known as *pure delay.* Pure delay exists when the movement of the DV responds to movements in the IV some period earlier. Once these variables are discerned, the only other data required to construct the model would be the turnover rates themselves, as these are the events that are to be predicted.

Calendar Year Data

In searching for variables that would successfully predict pilot turnover three years in advance, the author learned that most models used by Air Force planners deal with data in fiscal years (FYs). A fiscal year currently runs from October 1 in one year to September 30 of the next year. Therefore, to properly *lag* IVs to some point in time prior to the movement of the DV, similar time units should be used. However, if one were more interested in demonstrating actual causality between a set of IVs and the DV, similar time units may not be so critical. Indeed, if one were to closely examine the data used in some long-term forecasts, one would see that even though a time unit may be the same for the IV and DV, as the lagging increases, the relative significance of maintaining the same time unit decreases.

This research will attempt to predict pilot turnover three years ahead of the fiscal year in which it occurs. Obviously, pilots will be leaving the Air Force during the entire FY. Thus, any attempts to truly model turnover with consistent time units should attempt to do so with monthly or even weekly data. While some economic data do exist in monthly or weekly formats, they may not be valid predictors of the DV.

The author believes that identifying valid causal variables is more important than a perfect time unit match. Since most IVs the author researched are expressed in terms of the calendar year, this will be the time unit of the IVs, while the time unit of the DV will be in fiscal years. Clearly, any classical regression notation with lagged variables would have problems accommodating such a departure. While the author recognizes this, he believes that the actual predictability of the DV is of greater concern. If the reader has difficulty accepting this departure from standard data management techniques, the author suggests that it may be easier to view the IVs as being lagged by 33 months, rather than the 3 years (36 months) suggested in the research objectives section of the previous chapter. To avoid confusion, however, the author will continue to refer to the IVs as simply being lagged by 3 years.

Description of Data

Peter Drucker, in *The New Realities,* discusses the inability of economic theory to predict future events:

> Every earlier economic theory postulated that one such economy [microeconomy, macroeconomy] totally controls; all others are dependent and "functions." In the marginal-utility world of the neoclassicists, the microeconomy of individuals and firms controls the macroeconomy of government. In the Keynesian and Post-Keynesian worlds, the macroeconomy of national money and credit controls the microeconomy of individuals and firms. But economic reality now is one of three such economies. And soon the economic region (as in the European Economic Community), may become a fourth semi-dependent economy. Each, to use a mathematicians term, is a partially dependent variable. None totally controls the other three; none is totally

> controlled by the others, either. Such complexity can barely be described. It cannot be analyzed since it allows of no prediction. (6:157)

So, accurately predicting the movement of a large, complex, economy is not possible. While econometric methods use mathematical models and statistical inference to forecast future events, today's economy is controlled by factors that are not statistically significant. Consider the *Butterfly Effect*, a rigorous, albeit whimsical, mathematical proof that shows how a butterfly flapping its wings in the Amazon jungle affects the weather in Chicago weeks or months later. The point is, in a large, complex economy, the insignificant events are likely to be the ones with the greatest impact. Furthermore, these events, by definition, can be neither anticipated nor controlled. Indeed, they may even go undetected even after they have had their impact. (6:165-166)

Thus, an aggregate model of today's complex economy is not possible. Yet, if one were to view the economic world as a "very large and interdependent system of simultaneous stochastic equations" (3:309), then the basis for decomposing the economy into areas of predictability exists. In the world of econometrics, this is done by assuming the impact of some variables is so miniscule, that by treating them as zero will result in very small errors when estimating the impact of the variables included in a regression equation (3:309). Thus, while Drucker maintains that current economic theory cannot entirely explain the complexity of today, "theorems -- formulae and formulations to describe this or that phenomenon and solve this or that problem ...[are still possible]" (6:157).

Searching for economic variables that predict USAF pilot turnover may appear to be a monumental task. However, if one refers to the Mobley Intermediate Linkages Model of the turnover process, some guidelines may be established for variable inclusion. The author has limited his search to those economically related quantifiable variables that either cause a pilot to experience job dissatisfaction or cause alternative employment to become available.

Data Variables.

The following list of economic indicators will be investigated for inclusion as explanatory variables in the regression model to be constructed. They are presented in the following format: data title, *(short title)*, data description and justification, and data source. Appendix A contains the data sets described below.

Pay Compensation - (comp) - This variable measures the relative difference between military and civilian earnings. It is stated as the ratio between military and civilian pay, so a figure of 1.0 would denote complete equality, while those less than 1.0 would show greater economic reward in the civilian sector, with figures greater than 1.0 showing the opposite. This variable should explain economic job satisfaction or dissatisfaction experienced by pilots. If the ratio increases, turnover should decrease (25:16-17). (Note: the value for 1974 was not available. The author estimated 1974 using simple linear regression.) Source: Headquarters Air Force Military Personnel Center (HQAFMPC)/DPMYAP.

Percent of Population in Age Group 25 to 64 - (perc) - This age group would most likely contain the major portion of the business travelling public. Since most air travel is performed by businessmen (21:154), increases or decreases in its size may foretell similar airline activity. Source: U.S. Bureau of the Census, *Current Population Reports*, Series P-25.

Net Population Increase, per 1,000 Population - (netgrow) - Although this would be a very broad indicator of eventual increases in economic activity, it may have some value in the long-term prediction of that activity. This figure is derived by subtracting the death rate from the birth rate, and adding the immigration rate (all per 1,000 population) from the same year. Source: the same as for perc.

Civilian Labor Force Participation Rate - (lfpart) - This figure represents the proportion of the noninstitutional civilian population in the civilian labor force. The civilian labor force is comprised of all civilians classified as employed or unemployed. As labor force participation increases, one may find a positive correlation to airline activity and hence, the need for pilots. Source: U.S. Bureau of Economic Analysis, *Survey of Current Business.*

Net Business Formation - (nbf) - With a base year of 1967 (where 1967 = 100), this data records the change in business incorporations less business failures. As the value of this indicator increases or decreases, so should economic and hence, airline activity. One would expect then to find a positive correlation between increases in this statistic and pilot turnover. Source: U.S. Bureau of the Census: *Statistical Abstract of the United States;* also: *Survey of Current Business.*

Civil Aircraft Shipments - (acship) - The number of large transports (greater than 70 passenger capacity), shipped per year. A positive correlation may exist between the addition of new aircraft to airline fleets and future pilot demand by those airlines. Source: *Statistical Abstract of the United States.*

Aerospace Sales, Net New Orders - (sales) - Derived from reports submitted by companies whose principal business is the development and/or production of aircraft, aircraft engines, missile and spacecraft engines, missiles and/or spacecraft. Figures represent new orders received during the year less cancellations. Dollar figures are reported in then-year dollars (billions), and must be adjusted to a base year. The overall Gross National Product (GNP) implicit price deflator (1982 = 100) will be used to convert these data. The result may have a predictive effect on airline hiring, since new aircraft ordered by airlines will eventually increase the demand for pilots in the overall industry. Source: U.S. Bureau of the Census, *Current Industrial Reports*, Series MA37D.

Machine Tools, Orders and Shipments - (cut/form/mttot) - Since metal cutting and metal forming are two primary processes by which aircraft and their subsystems are manufactured, orders for machines that perform these functions may have a long-term predictive ability on aircraft manufacturing and airline hiring. Since data is available on either the cutting (cut) or forming (form) tools, three IVs will be investigated: cut, form, and if neither proves significant alone or in combination, the total (mttot) will then be investigated for possible inclusion in the model. Data are reported in then-year dollars (millions), and must be converted to a base year for comparison purposes. Conversion will be accomplished in the manner described in the previous variable's discussion. Source: U.S. Bureau of Economic Analysis, *Business Statistics*; also: *Survey of Current Business*.

GNP Implicit Price Deflator - (GNP) - An implicit price deflator is derived as the "ratio of a current dollar estimate (for GNP or a component) to its corresponding constant dollar estimate multiplied by 100. . . . Changes in an implicit price deflator reflect not only changes in prices but also changes in the composition of GNP or a component" (2:303). Changes in the deflator itself may have some broad explanatory ability on the availability of future employment alternatives for the workforce in general (31:232). Source: U.S. Bureau of Economic Analysis, *Business Statistics,* also, *Survey of Current Business.*

Scheduled Commercial Air Carriers, Percent Load Factor - (lofac) - This data is derived by dividing the revenue passenger miles flown by U.S. scheduled air carriers on domestic routes by the actual number of available seat miles by the same carriers on the same routes. This data would reveal not only current airline industry health, but also the level of demand for airline services. Thus, as lofac increases, airlines may be inclined to expand their services to accommodate increased demand. Such expansion may then result in increased pilot demand. Source: U.S. Federal Aviation Administration, *FAA Aviation Forecasts.*

Major Airline Pilot Retirements - (the one that got away) - The Future Aviation Professionals of America (FAPA) recently compiled a data bank to track the number of pilot retirements (due to age) the major airlines will experience. Theoretically, for an airline to maintain its current level of service, it would need to replace these pilots on a one-for-one basis. Unfortunately, this is a forward-looking data-base, and the historical data goes only to 1988. Thus, it would not be suitable for any current modeling purpose. However, FAPA was gracious enough to provide the author with a list of this data, and it is included as Appendix B, for future use by other modelers.

The Dependent Variable.

The variable intended to be predicted with the use of the above-mentioned variables is the voluntary retention rates of Air Force pilots. A retention rate is the percent of individuals who remain in the service out of those who have the opportunity to leave. This data is maintained by HQAFMPC Analysis Division. The year groups of interest are those which contain pilots who have completed their initial pilot training obligation, but have yet to "commit" themselves to an Air Force career. As discussed in the previous chapter, current retention efforts are aimed at those pilots in the 7 to 14 year groups. Therefore, these are the year groups whose retention by the service this research intends to predict.

Overview of the Analytical Model

"Regression Analysis is a statistical tool that utilizes the relation between two or more quantitative variables so that one [the dependent variable] can be predicted from the other or others [the independent variables]" (19:23). Typically, regression analysis is the method of fitting a line to a series of plotted data points on a cartesian plane in such a fashion that the line is the best estimator for the values plotted. Since this line can be stated with a mathematical formula, it may then be used to predict future values of the dependent variable. The formula used to depict this line is known as the General Linear Model, and may be expressed as follows:

$$Y_j = \beta_0 + \beta_1 X_{j1} + \ldots + \beta_K X_{jK} + \varepsilon_j$$

where:

Y_j is the value of the dependent variable on the *jth* trial
$\beta_0, \beta_1, \ldots, \beta_K$ are parameters to be estimated
$X_{j1}, \ldots, X_{jK}$ are known constants, the value of the independent variables in the *jth* trial
ε_j are error terms (the difference between the observed and predicted value of Y_j) (19:31)

Estimators of the regression parameters are found using the method of least squares, where, for each observation (X_j, Y_j), an expected value is computed. This expected value is then subtracted from the observed value of Y_j and squared. The result is minimized when fitting the regression line, with use of the *best* estimators (19:38). These parameter estimates are known as regression coefficients.

Assumptions of the Model.

The following are basic assumptions of the GLM:

- The relationship between the IVs and DV is linear. That is to say, the magnitude of a coefficient does not change with movement (change) of its IV.
- Error (ε_i) is a normally distributed random variable with a mean of zero, and a constant variance between observations.
- Independence of ε_i implies the errors are uncorrelated.
- The IVs are statistically independent of each other (7:62, 19:52).

Use of the Model.

Once the best estimators of the regression parameters have been determined, the regression model may be written and plotted. Provided the predictor variables exhibit enough pure delay, future values of the dependent variable (pilot retention rates), may then be accurately predicted.

III. *Methodology*

Aggregate Versus Disagggregate Models

Regression models have shown strong relationships between explanatory variables and employee turnover on an aggregate level (29:847). However, once the same data used in an aggregate model are disaggregated, the relationships between the same IVs and the disaggregated DVs becomes inconclusive (29:848). Thus, regression models may be inappropriate for disaggregated data.

Data must be disaggregated to some extent in order to employ regression techniques (3:309). However, disaggregating to a level of detail that produces no predictive ability, by the IVs of turnover, may result from this data decomposition process. Since Captain Simpson's research produced a valid regression model with turnover data by *years of service* (YOS), the author developed models that use data at the same level of detail to obtain predicted turnover rates. The difference between the two models is the amount of lead time provided, thus necessitating an ostensibly different set of IVs.

Developing the Basic Regression Model

Construction of a regression model is a highly iterative process that results in estimates the $\beta_{j..k}$

values to give the best fit. Fortunately, computer packages exist that run these iterations in a fast and virtually error-free fashion. For the purpose of this research, the programs, *SAS* and *Statistix*, were used to compute values of the dependent variable and to perform tests on the validity of the model. In addition, other software (*MathCAD*, *Quattro*) was utilized to provide random numbers and graphic capability, respectively.

Variable Inclusion.

In chapter two, eleven variables were identified for possible inclusion in the model. The next logical step is to then decide which variables should indeed be included. As was noted earlier, the variables which should be included should have an explanatory effect of the DV. This is known as causality.

> ...causality...[is defined]...such that X causes Y *if and only if* the variance of the error [or the mean square error, Pierce and Haugh (1977)] in forecasting Y is lower if the information on X along with all other relevant information is used in forecasting Y, compared to the variance of the forecasting error when knowledge of X is not used in forecasting Y. (12:196)

Thus, a variable should be excluded if it does not reduce the amount of variability, and hence, error the regression parameters exhibit in their explanation of the DV.

Stepwise is a *SAS* procedure that automatically considers an IV's causality. Using the *MAXR* option with this procedure, the best 1...*n* variable model is built, with the criterion for variable inclusion being whether the variable increases the model's measure of R^2 (25:765). The *MAXR* option will build at most eleven models from a data set that contains eleven IVs. Fewer models will be built by the procedure if no improvement in R^2 can be obtained with the addition of another IV.

The Coefficient of Multiple Determination.

In regression analysis, R^2 is the symbol for the *coefficient of multiple determination.* "It measures the proportionate reduction of total variation in Y associated with the use of the set of X variables . . . " (19:241). R^2 may range in value from zero to one, with one being a perfect fit of the IVs to the DV (where no error exists). The closer R^2 is to one, the greater the accuracy of the model becomes. As more variables are added to the model, R^2 will inevitably increase, regardless of the amount of variation the new variable explains (19:241). *MAXR* compensates for this by adding variables to the model in the order of which ones produce the *greatest* increase in R^2.

Adjusted R^2.

Determining which model to initially test, however, should not be based on the size of R^2, but *adjusted R^2* (R_a^2). R^2 is adjusted by dividing each of its components by its respective *degrees of freedom.* The formula for R_a^2 is:

$$R_a^2 = 1 - \left[\frac{n-1}{n-p} \right] \frac{SSE}{SSTO}$$

where:

n is number of observations associated with the IVs
p is the number of parameters that must be estimated
SSE is the sum of the squared errors between the predicted and actual values of the DVs
SSTO is the sum of squared deviations about the sample mean of the DVs (19:236-241)

Degrees of freedom ($n - 1$ and $n - p$) may thus be seen as a tool to mitigate the effect on R^2 that adding more variables to the model has.

Selecting the Model.

Once the *MAXR* results were returned from a *SAS* run, the coefficients of model candidates were examined for their significance in the model. Traditionally, the levels of significance, or *alpha* values, used in model building have been .1, .05, and .01. With the advent of computers and the appropriate software to perform virtually all of the calculations involved in this highly iterative process, however, alpha values are viewed less as a concrete decision tool to be used to determine whether to accept or reject a particular IV for model inclusion, and more as a relative indicator of the validity of the model. Thus, while smaller alpha values indicate a better model fit, relatively large alphas need not necessarily be viewed as the sole cause for rejecting a model parameter.

Obviously, several adequate models may present themselves as valid candidates for consideration as the best model to eventually use for forecasting retention rates. However, merely choosing the model that has *the* highest value of $R_a{}^2$ is not the sole criterion for model selection. As previously discussed, econometric modeling is partly a science and partly an art. The author views the art portion as the variable selection process. Chapter 2 discussed the logic behind selecting variables for consideration. Once a model with a high $R_a{}^2$ is built, however, the variables used in this model must again be assessed for their ability to capture the synergy of the turnover process. Thus a two-variable model that has an $R_a{}^2$ of .95 might be rejected in favor of a four-variable model that has a slightly smaller $R_a{}^2$.

Validating the Model Internally.

The GLM is validated internally by several methods. The General Linear Test (GLT) uses the test statistic, F, to determine whether or not the values for the regression coefficients are zero:

> The overall significance of the regression can be tested with the ratio of explained to the unexplained variance. This follows an F distribution . . . . If the calculated F ratio exceeds the tabular value of F at the specified level of significance and degrees of freedom, the hypothesis is accepted that the regression parameters are not all equal to zero and that R^2 is significantly different from zero. (24:145)

SAS and *Statistix* compute an *F*-value as well as a probability of obtaining a larger *F* if the regression coefficients are indeed zero. This probability is called *significance probability (P),* and provides a basis for accepting or rejecting the model's parameter estimates: the smaller the probability, the greater the validity of the model.

Similar tests are performed for each parameter. A *t-value* for each parameter estimate is computed by dividing the estimate by its standard error. A probability of deriving a greater absolute value than that of the computed t-value if the parameter were indeed zero is then computed. This research will refer to this probability as the parameter's *level of significance,* or *p-value.* Again, the smaller the p-value is, the greater the validity of the model in general, and the parameter estimate in particular.

Aptness Analysis.

Other internal tests of the model should be accomplished to ascertain whether or not the assumptions of the GLM are violated. Such testing is usually done through analysis of the residuals obtained in the regression, and generally falls under the title, *aptness analysis,* or testing for the data's ability to model the DV. According to Neter, Wasserman, and Kutner, there are six departures that may be studied to ascertain a model's aptness:

1) The regression function is not linear.
2) The error terms do not have constant variance.
3) The error terms are not independent.
4) The model fits all but one or a few outlier observations.
5) The error terms are not normally distributed.
6) One or several important independent variables have been omitted from the model. (19:116)

As previously stated, a regression function is linear if the magnitude of the regression coefficients does not change with the magnitude of the of the independent variables. Thus, as more data sets are added to the model, the coefficients should not appreciably change. Therefore, one may test for linearity by comparing coefficients in the original model to those obtained after more data are added. In a model building scenario, this concept may be difficult to diagnose, since testing and validation, depending on the data producing situation, may require that data sets be withheld. In such cases, it must be assumed that enough cases were originally included in the model to provide valid estimates of the parameters. The author will test for linearity by comparing the coefficients obtained with the twelfth data set, to those using the last complete data set, the thirteenth.

To check for *heteroschedasticity*, or the lack of a constant error-term variance, a plot of the errors (known as *residuals*), versus the predicted values is helpful. Residuals should be scattered in a band of constant width around a mean of zero, which indicates constant error-term variance.

In Captain Simpson's thesis, heteroschedasticity was addressed by performing a logarithmic transformation of the dependent variable. For the purpose of simplicity, the author assumed that heteroschedasticity exists, and while it was investigated, remedial measures were limited to the logarithmic transformation outlined in Simpson's methodology:

$$trate = -\ln(UB - rate + \delta)$$

where:

trate = the transformed dependent variable
rate = the voluntary retention rate
UB = the upper bound of the rates (1.0)
δ = a small constant (.001)

The constant, delta, was determined by the size of the largest retention rate in the data. This occurred in year group 14, where the highest rate observed was .9915. The reader is referred to Captain Simpson's methodology for a further discussion of this variance stabilizing technique (26:33).

Autocorrelation is defined as the correlation between the residual in one time period and that in the previous time period. If autocorrelation is present, non-independence of the residuals is implied. This is common in time series analysis, and may be detected with the use of a *runs* test (19:130). The runs test performed by *Statistix* orders the *standardized residuals* by their magnitude, and then plots them about their mean (residuals are standardized by dividing them by the mean of the regression's squared error [MSE]). The number of runs (two or more consecutive values above or below the mean) is then tabulated. Too few runs indicates positive autocorrelation, while too many runs indicates negative autocorrelation (27:8.3).

When a runs test is used in this manner, it is known as a *Wald-Wolfowitz* runs test (4:350). The Wald-Wolfowitz test statistic, *T*, is the total number of runs observed. A table of values for this statistic must then be consulted to determine if the residuals are random (and hence independent). For the sample sizes involved in this research, *T* should be greater than two but less than ten to conclude randomness at a .05 level of significance (4:414).

Outliers are values of the DV that cannot be accurately fit by the model. They may exist in some regressions and remedied by omitting them. However, a rationale for omission, such as measurement or recording error, should exist (20:505). Since the DV is the retention rates of USAF pilots, the author can think of no reason to omit outlier observations, if they do indeed exist. Therefore, while the model that is ultimately produced may contain a poor fit at some locations, no remedial action will be taken upon such deviations.

Normal distribution of the residuals of the regression model may be ascertained by use of the approximate Wilk-Shapiro statistic.

> If the assumptions of multiple regression are met, the standardized residuals should be approximately normally distributed with mean 0 and variance 1. The i-th rankit is defined as the expected value of the i-th order statistic for the sample, assuming the sample was from a normal distribution. The order statistics of a sample are the sample values reordered by their rank . . . . The approximate Wilk-Shapiro statistic calculated is the square of the linear correlation between the rankits and the order statistics (Shapiro and Francia 1972) . . . non-normality . . . [is indicated by] . . . a small value for the Wilk-Shapiro statistic. (27:8.5)

The analysis in this research used a critical value of 0.9 to test the approximate Wilk-Shapiro statistic obtained in Statistix output to conclude whether or not the error terms are normally distributed.

The investigation for omission of several important variables from the model requires a plot of residuals versus the independent variables omitted. This plot would reveal any important descriptive power of these omitted variables (19:128). Since this model building effort dealt with a variety of broad economic indicators, it was assumed that the model generated, based upon a high value of R_a^2 (with the corresponding decrease in model error), would not omit any significant variables. This is not to say that other significant variables may not exist, rather, that such variables have not initially been included for investigation and testing.

Thus, this research effort's aptness analysis will consist of:

- A comparison of coefficients to confirm linearity,
- Residual plots to reject heteroschedasticity,
- The Wald-Wolfowitz runs test to confirm error-term independence, and,
- The approximate Wilk-Shapiro statistic to confirm the normal distribution of the error-terms.

Multicollinearity.

Another widely used method, though not related to aptness analysis, used to determine a model's internal validity is to examine the IVs for *multicollinearity*. "*Multicollinearity* refers to the case in which two or more explanatory variables in the regression model are highly correlated, making it difficult or impossible to isolate their individual effects on the dependent variable" (24:182).

Still, if the intent of the regression is not to isolate the effects of the IVs on the DV, but to predict the DV, multicollinearity (and the corresponding inability to conduct sensitivity analysis with the IVs), even though it may exist, may be seen as a small penalty if the predictive ability of the model is of primary concern. Neter, Wasserman, and Kutner provide an example of this concept, using two variables that are perfectly correlated. They conclude:

> The fact that some or all independent variables are correlated among themselves does not, in general, inhibit our ability to obtain a good fit nor does it tend to affect inferences about mean responses or predictions of new observations . . . "(19:300).

The broad nature of some of the IVs that are to be investigated necessitates the assumption that multicollinearity exists between some of them. Rather than use this relationship as a basis for omitting variables from the model, the author invokes the rationale stated above as the basis for not investigating it further, since predictive ability of the IVs on the DV will not be impaired.

Standardized Variables.

A standardized variable is one that has its sample mean subtracted from it, and is then divided by the sample standard deviation. The resulting value is the number of standard deviations the non-standardized value lies from the sample mean. Thus, a standardized variable has its scale, or unit of measure, removed and all variables then have a common unit: their sample standard deviation. In multiple regression (regression with more than one independent variable), standardized variables are required to do any meaningful sensitivity analysis. Since this research will exclude sensitivity analysis, and instead concentrate on obtaining accurate predictions, standardizing will not be performed.

Validating the Model Externally.

External validity of the model is achieved through accurate prediction of the dependent variables. This will be accomplished by withholding data sets twelve and thirteen until a candidate model has been built. This model will then be internally tested with the addition of data set twelve. If R_a^2 remains at a high level, and the IVs remain significant, then the model will be externally validated by predicting the DV in data set thirteen. If a reasonably close prediction is obtained (where the DV falls within the 95 percent prediction interval determined by Statistix output), this data set will in turn be added to the model to generate a final set of coefficients.

If the candidate model fails these tests, a model using a different combination of variables will be sought and similarly tested. Once a candidate model passes these tests, it will then be subjected to the more rigorous internal validity tests discussed in this chapter before the decision to ultimately accept or reject the model is made. The final set of coefficients will then be used to predict retention rates by YOS in FYs 90 to 92.

Meeting the Research Objective

This model intends to meet the research objective of predicting Air Force pilot retention three years in advance, through the use of regression analysis techniques.

IV. *Findings and Analysis*

Introduction

This chapter will examine refinements to the methodology discussed in the previous chapter and the results produced by models built with the original and refined processes.

Initial Model Attempts

The author originally intended to closely follow Captain Simpson's methodology in deriving a workable model for pilot retention in year groups seven through fourteen. Captain Simpson was able to build one model to provide output for all year groups (in his research, year groups seven through eleven), with the aid of dummy variables. This is a common technique used in regression models and it worked well in Captain Simpson's effort. However, since the model the author wished to produce required more pure delay from a different set of independent variables, he was not able to build a similar model that could produce valid estimators of the β coefficients for each year group.

Virtually no parameters in this initial model were found to be significant, even to a level of 0.25. The highest R_a^2 the author could obtain following Simpson's methodology was .35, which the author deemed unacceptable.

The author then ran the *MAXR* procedure in *SAS* without the use of dummy variables. This necessitated a modeling effort for each individual year group. *SAS* returned several good models for each year group. The author examined models based upon the highest value of R^2 (since *MAXR* does not return a value for R_a^2), with variables that exhibited at least a 0.1 level of significance.

These models were built using the first eleven data sets. The testing phase, as discussed in chapter three, involved adding the twelfth data set to the models, and investigating their parameters for significance. This had extremely negative effects on the model parameters, as all of the models, except for 10 YOS, failed to maintain parameter significance.

The DVs for each year group were subsequently examined. It was noticed that for the first eleven observations, most of the variability of the DVs was confined to a relatively narrow band, while the last two observations varied greatly from this band of previous observations. It was therefore decided to include data set twelve in the variable selection process, and once a candidate model was built, to again check for significance of the parameter estimates produced with these variables, using only the first eleven data sets. The thirteenth data set was still withheld for validation purposes.

Deviations From the Planned Methodology

The author again used the *SAS* procedure, *MAXR*, to identify potential models for testing, but with the use of twelve data sets. The results were less than encouraging. As may happen when data is collinear, a model with a high R^2 may produce parameter estimates that are not significant. Similarly, a model with a high R^2 does not necessarily guarantee that the model $R_a{}^2$ will be commensurately high. Herein lies a flaw in the *MAXR* approach to model building, as the *MAXR* output only produces the models with the **highest** value of R^2 and these models may contain flaws not discovered until subjected to other internal tests. Thus, the author ended his use of *SAS* as a model building tool, and retained only the 10 YOS model produced by the initial methodology.

Statistix software was thereafter used exclusively for model building, testing and validation. *Statistix* offered two main advantages over *SAS*: it was run on a personal computer (PC), which meant obtaining quicker results, and it had a different model building tool for linear regression, *All Subset Regression.*

An all subset regression produces a model for each possible combination of variables, regardless of the values of R^2 or $R_a{}^2$ that result. The modeler must then choose which models he should investigate further, based upon the limited results produced by the *All Subset*

Regression procedure. For a model with M potential IVs, $2^{(M-1)} - 1$ models would be built. Thus, the 11 IVs researched in this effort produced 1023 subset regressions for each year group modeled. The author limited his search for potential models to those that had the highest values of $R_a{}^2$. This resulted in anywhere from ten to thirty models to be investigated further. Again, the first twelve data sets were used, because of the problem with DV variability encountered earlier.

These models were then investigated for significance of the regression coefficients, and the author selected the single model for each year group that produced the most significant parameters. Data set twelve was then withheld, and the regression was done again to ascertain parameter significance using only eleven data sets.

Transformation to Check External Validity

If the parameters remained significant, data set twelve was added to the regression, and the coefficients produced were then used to forecast the DV in data set thirteen. The forecast value returned, though, was expressed in the terms of the transformed DV, discussed in chapter three. To make the forecast numbers meaningful, they were transformed back to a rate with the use of the following formula:

rate = 1.001 - (1/exp(fval))

where:

rate = the forecast value transformed to a rate
exp = *e* (the base of the natural logarithm system) raised to the power (x)
fval = the forecast value returned by the model and the power to which *e* is raised

If the DV's actual value was within the 95 percent prediction interval of the predicted value, the prediction was deemed valid.

Accepting or Rejecting the Model

Aptness analysis was conducted for all models, first using only eleven, then twelve, and finally all thirteen data sets. Forecasts were made, using the final coefficients and data sets fourteen, fifteen, and sixteen, for FYs 90, 91, and 92 respectively.

Generally, if these tests for internal and external validity were not passed, a different model was then selected for testing. However, one or two minor deviations did occur from these test specifications, and in these cases, the model that ultimately was produced was the best model possible, even though its internal or external validity was below the level desired. These deviations will be addressed in the discusssion of the particular models in which they occurred.

Alternate Forecasts

As forecasts were prepared for each year group, the IV data from sets fourteen and fifteen were of no use in furthering the refinement of the model's parameter estimates, as there were no DVs to regress them against. To include these data for that purpose, a method for estimating the DVs for data sets fourteen and fifteen was required.

One may initially think that the forecasts themselves may be used as the DV in these data sets. However, the forecast itself has no error component, so the addition of these data sets with forecast values as the DVs produces the same results as the original model. Thus, a method for adding error to the forecast value of the DVs had to be established.

This was accomplished by generating random numbers, between zero and six, with the use of *MathCAD* software (16). Error in a regression is assumed to be a normally distributed random variable with a mean of zero. Therefore, three was subtracted from the random number generated, to represent the number of standard deviations, either above or below the mean, the fictitious DV rested (it was assumed six standard deviations encompassed the entire area under the normal curve). (Note: Caution should be exercised when generating random numbers with *MathCAD*. If random numbers are produced using *MathCAD*

Version 2.5, the same set of numbers will be produced each time the program is initialized, or if the randomize command is used, because the seed of the random number generator will be reset [16:172].)

The result was multiplied by the standard deviation of the error term, and added to the forecast value, to produce an estimate of the DV. This value was then included in data set fourteen as the DV, and the entire process was repeated to produce an estimate for the DV for data set fifteen. Finally, another regression was done with the fifteen data sets, and the coefficients produced by this regression were used to forecast the DV in FY 92, using data set sixteen. The results of this alternate methodology are found under the title "alternate" in Appendices E and H.

Analysis of the Models

The models will be discussed separately, since each is unique. The method of arriving at the final models followed one of three paths: 1) by the original methodology outlined in chapter three; 2) by the adjusted methodology outlined in this chapter; or, 3) by the adjusted methodology with the inclusion of other variables (which will be discussed when they occur in a particular model).

Appendices C, D, E, and F contain data used to internally and externally validate the models. Appendix C contains regression coefficients for the various model variables, and significance levels (p-values) for the same. Appendix D contains values for the: R^2, $R_a{}^2$, Model P, T, and the Approximate Wilk-Shapiro statistic. The interpretation of these values was discussed in chapter three. Model forecasts are in Appendix E. Appendix F contains the graphs of residuals versus predicted values, to check for heteroschedasticity.

Models Using the Original Methodology.

As previously stated, the 10 YOS model was the only one developed with the original methodology. The model returned by the *MAXR* option consisted of the following IVs: cut, nbf, netgrow, perc, and comp. The model parameters remained significant to a level of 0.01 throughout the last three data sets. Aptness analysis revealed no deviations. The model predicted a retention rate of 0.7342 in FY 89 (using the first twelve data sets) with a 95 percent prediction interval of 0.5216 to 0.8616. The actual value was 0.6944. The forecast rate for FY 92 is 0.7138.

Models Using Adjusted Methodology.

7 YOS.

The model developed to predict retention within the 7 YOS group used the following IVs: cut, lofac, nbf, netgrow, and comp. All parameters were significant to a level of .0814 in both the twelve and eleven data set regressions. The best model obtainable at this significance level returned an $R_a{}^2$ of only .8073 in the 12 data set model, though this increased to .8632 in the final model (which used the first thirteen data sets). Aptness analysis revealed one minor deviation. The Approximate Wilk-Shapiro value of .8959 from the 12 data set regression did not meet the 0.9 level desired to assert error-term independence. This value returned to .9349 in the final model. The author does not view this deviation significant enough to reject the randomness assumption. The twelve data set regression predicted a retention rate of 0.4535 for FY 89 with a 95 percent prediction interval of 0.0078 to 0.6992; the actual rate was 0.4070. The forecast rate for FY 92 is 0.4685.

9 YOS.

The 9 YOS model developed consisted of the following IVs: cut, nbf, netgrow, perc, and comp. Parameters were significant to a level of .049 in the twelve and eleven data set regressions. $R_a{}^2$ remained high through all regressions, with a minimum value of 0.9528. Aptness analysis revealed no deviations. The twelve data set regression predicted a retention rate of 0.6851, with a prediction interval of 0.5089 to 0.7983. The actual rate for FY 89 was 0.6374. The forecast rate for FY 92 is 0.6256.

11 YOS.

The model originally produced by the adjusted methodology was comprised of the IVs sales, netgrow, gnp, and comp. This model was slightly more valid internally and externally than the one ultimately selected and described below. It was not selected because it was discovered that sales not only included civilian but military aerospace orders and was therefore too broad of an indicator to be appropriate for inclusion as a predictor of the DV. Although disaggregated sales data is available that excludes military orders, this fact was not discovered until it was too late to alter the data sets and perform further model building efforts.

Lfpart, gnp, comp, nbf, and netgrow comprise the IVs used to predict the 11 YOS year group. Model parameters were significant to a level of 0.074 through the twelve and eleven data set regressions, though the final model saw nbf's significance drop to 0.119. Regressions without this variable were executed, but the resultant model's internal and external validity decreased. Therefore, it was decided to retain nbf in the model. The final model produced the lowest value of R_a^2: 0.8617. Aptness analysis revealed no deviations, but linearity was investigated by a secondary method, since the ceofficients from the twelve and thirteen data set regressions differed by a greater degree than that shown by most of the other models.

The secondary method chosen was suggested by Neter, Wasserman, and Kutner in their book, *Applied Linear Regression Models* (19:118-120). A plot of the residuals over time should depict the residuals lying in a horizontal band centered around zero. Appendix G contains the plots for the models that required the use of this additional test. From the plot for 11 YOS, it was concluded that the IVs were indeed linear in their explanation of the DV.

The twelve data set regression produced a forecast of 0.9028, with a prediction range of 0.7744 to 0.984. The actual rate was 0.7911 for FY 89. The forecast rate for FY 92 is 0.8769.

14 YOS.

The 14 YOS model consisted of the following IVs: cut, lofac, nbf, netgrow, and comp. Parameters were significant to a level of 0.10 through regressions with data sets twelve and eleven. However, netgrow's significance fell to 0.1194 for the final model. As with nbf in the 11 YOS model, this variable was excluded from the regression and the tests for internal validity conducted again, with poorer results obtained. Netgrow was accordingly reinstated to the model. R_a^2 remained high through all regressions, with a minimum value of 0.9304. Aptness analysis revealed no deviations. The twelve data set regression produced a forecast of 0.9528, with a prediction interval of 0.9105 to 0.9753. The actual value for FY 89 was 0.9315. The forecast rate for FY 92 is 0.9534.

Models Using Additional Variables.

Three year groups (eight, twelve, and thirteen) could not be predicted, at the same level of validity attained in the previous models, solely by the use of the economic indicators described in chapter two. Further examination of the DVs from each year group revealed that the retention rates of some year groups may have a predictive effect on the rates of other year groups. This relationship was first noticed between year groups eleven and twelve. The 12 YOS model was by far the most difficult to build, and is discussed first. The other models are examined in the order in which they were built.

12 YOS.

The best pure econometric models of the twelve year group produced an R_a^2 in the 0.70 to 0.79 range, and were therefore deemed unacceptable. Rather than accept a low R_a^2, the author decided to digress from pure economic IVs in order to obtain models with greater validity. By examining the DVs from the eleven and twelve year groups, it appeared that the twelfth year group's rates mirrored those of the eleventh year group. From the author's experience as a pilot in a strategic airlift squadron, this made sense, since he witnessed the decision making process of several pilots who left the Air Force, and developed the scientifically unfounded belief that the decision to leave is in part motivated by peer pressure. Thus, the decision to investigate the impact of peer group retention rates was made.

As mentioned previously, a relationship between the twelve and eleven year group retention rates seemed to exist. If the year group below might be significant in influencing the decision to stay or leave, it was reasoned that the year group above may have a similar impact. It was therefore decided to investigate the possible effects of these year groups' retention rates on retention in the twelve year group.

Defining the IVs necessitated some creative data management. Initially, the rates of the peer groups themselves were intended to be used. However, this method has a major flaw: since the models are meant to predict retention three years ahead, the retention rates of the peer groups would not be known. Therefore, forecasts for the last three complete data sets (eleven, twelve, and thirteen) were used in place of the actual rates. In addition, the rates themselves were not used as the IVs, rather, the transformed rates, as described in chapter three were required. Regressions using both the original rates and transformed rates were attempted, and the models using transformed rate IVs produced results within the range of valid predictions (zero to one), while the original (untransformed) rate IVs did not.

While forecast rates were used in the last three data sets to build the models, the actual rates were used for validation and forecasting purposes. Since the actual rates were indeed known, in order to produce the best possible forecasts, it did not make sense to withhold them from the entire process.

Three 12 YOS models were produced. 12 YOS "A" used one IV, *trate11* (the transformed retention rate for year group 11). 12 YOS "B" is comprised of trate11 and *trate14* (the transformed retention rate for the fourteen year group). While the original intent was to use the transformed rate from the thirteen year group, it was decided that, since the 13 YOS model itself required the use of an adjacent year group's retention rate as an IV (the fourteenth), using the fourteen year group's transformed rate would produce models with greater validity. 12 YOS "C,", a model using a combination of economic IVs and a retention rate IV, was arrived at using trate11, lfpart, gnp, and lofac.

Perhaps the reader may be able to discern the best 12 YOS model from the explanations below or from examining the test data. The author, however, is reluctant to flatly state which model is "best." Each has it strengths and weaknesses, which is why the three are presented.

12 YOS "A."

The simplest of the three models, 12 YOS "A" is the most internally valid as well. The single variable, tratell, produced phenomenal results. Parameters were significant to a level of 0.0 through all regressions, while R_a^2 had a minimum value of 0.8448. Aptness analysis revealed no deviations. The twelve data set regression predicted a retention rate of 0.7817 for FY 89 (with a prediction interval of 0.4877 to 0.9073). The actual rate was 0.5957. The forecast rate for FY 92 is 0.8712.

12 YOS "B."

12 YOS "B" is the least internally valid of the three models. Trate14's best level of significance did not occur until the final model and then it was still 0.2738. Tratell remained significant (0.0048) through all regressions. R_a^2 peaked at 0.8816 in the final model. Aptness analysis revealed no deviations, though linearity was tested with the method described in the 11 YOS model. The forecast from the twelve data set regression was 0.7572 for FY 89 with an interval of 0.3468 to 0.9101. The forecast rate for FY 92 is 0.8482.

12 YOS "C."

This model produced the best external validity, though internal tests were somewhat mixed. Parameters were significant to 0.0537 in the final model, but the significance of lfpart, gnp, and lofac was less in the twelve and eleven data set regressions, with all values ranging between 0.2 and 0.1. R_a^2 went from 0.782 in the eleven set regression to 0.9078 in the final model. Aptness analysis revealed no deviations. The forecast for FY 89 using twelve data sets was 0.5798 with an interval of 0.0 to 0.8832. The forecast rate for FY 92 is 0.7707.

13 YOS.

The 13 YOS model contained the following IVs: lfpart, lofac, perc, mttot, and trate14. Parameters were significant to 0.0791 through regressions with twelve and eleven data sets. However, mttot fell to a significance of 0.1946 in the final model. Regressions without mttot, and various combinations of its elements (cut, form), yielded no better results, so mttot was retained at the expense of the model's internal validity. Aptness analysis revealed no deviations, though linearity was confirmed via the method used with the 11 YOS model. R_a^2 fell from a high of 0.9519 in the eleven set regression, to 0.8424 in the final model. The twelve set regression produced a forecast of 0.7931 for FY 89, with an interval of 0.5357 to 0.9081. The actual rate was 0.9014. The forecast rate for FY 92 is 0.7999.

8 YOS.

The model for the eight year group was the last one produced. Initially, a fairly good model (cut, form, lfpart, perc, and comp) was built without the use of a "peer group" retention rate. However, this model's external validity test overestimated retention in FY 89 by 0.1028, and although this was within the 95 percent prediction interval, the author viewed overestimations of this magnitude as undesirable. Hence, a peer group retention rate was used to obtain greater prediction accuracy. The only other pure economic model that produced a larger overestimation was 11 YOS (0.1117), but since it was significant in the prediction of the twelve year group as well, no attempt to refine 11 YOS through the use of peer group variables was made.

The 8 YOS model ultimately built contained the IVs cut, nbf, gnp, comp, and *trate7* (the transformed retention rate from year group seven). Parameters were significant to a level of 0.1066 in the twelve set regression. The eleven set regression saw nbf's significance drop to 0.2523, which was initially viewed as a cause for rejection. However, tests without nbf, and substituting all other variables produced either similar or worse results in the eleven and twelve data set regressions.

Therefore, nbf was retained, though it detracts from the model's internal validity. The final model saw all variables significant to a level of 0.0855. R_a^2 remained high over all data set regressions, with a minimum value of 0.9257. Aptness analysis revealed no deviations. The twelve set regression produced a forecast rate of 0.5051, with an interval of 0.2224 to 0.6852. The actual rate for FY 89 was 0.4741. The forecast for FY 92 is 0.5136.

Summary

Adjustments to the original methodology were required to produce statistically valid models of year groups seven through fourteen. Some year groups could not be adequately predicted through economic relationships alone and thus peer group retention rates were required to help explain retention.

V. *Conclusions and Recommendations*

Introduction

This chapter will examine the practical implications of the research results, the policy implications for management, and recommendations for model refinement.

Practical Implications of the Results

A model for each year group, from seven to fourteen YOS was produced. These models demonstrated the ability to forecast pilot retention rates three years ahead, using statistically significant IVs. While perhaps models that contained greater internal validity could have been produced using all thirteen data sets, their external validity would have been unknowable.

Variable Analysis.

Since multicollinearity was not investigated, sensitivity analysis is not possible. The sign of the regression coefficients in the models produced, however, may be an indication the validity of these variables as predictors. Three variables: nbf, gnp, and comp, did perform as postulated in chapter two. The sign of the regression coefficients of nbf and gnp was negative, indicating that movement of these variables contributed to the opposite movement of the DVs three years later. The variable, comp, had a positive value, which suggests that as it decreases in value, so does the DV it helps to predict.

What is puzzling is that virtually all of the other IVs introduced in chapter two and ultimately used in the final models (cut, lofac, netgrow, perc, and mttot) did not behave in the manner anticipated. For example, the variable cut was significant in five models and had a positive value. The positive value suggests that as metal cutting machine tool orders increased in any one year, the effect on the movement of the DV was positive three years later.

The reason for this phenomenon is unknown, but may be due to one or more of the following hypotheses:

•The author's intuitive interpretation of lagging these variables for a period of three years may have been incorrect.

•The actual movement of these IVs may have a greater short-term impact on the DV than the relatively long-term (three years) this research encompassed.

•Since multiple regression analysis examines the combined effect of a set of IVs on the DV, interpretation of the signs of the regression coefficients may be more difficult.

•If multicollinearity exists, then any interpretation of the sign of the coefficient may be meaningless.

•Other reasons not postulated by the author.

Another tool used to analyze variables is the comparison of their regression coefficients. The magnitude of these coefficents reveals the relative importance of the various variables in a model. However, to apply this technique, the variables must be standardized, as discussed in chapter three. Early in this research, it was decided that the predictive ability of the models was of prime importance. Hence, sensitivity analysis and the relative importance of the variables in a particular model were not deemed to be within the scope of the research. In retrospect, such analyses may be of interest to users of these models, and will therefore be included as suggested model refinements.

The Mobley Paradigm.

That this research produced statistically valid models is but the first step in reversing the trend in pilot retention the Air Force is experiencing. The information these forecasts will provide should signal leadership as to whether or not previous trends will continue. Using the Mobley paradigm for turnover management, these models should allow Air Force leaders to *anticipate* the turnover event. If the forecasts are unacceptably low, policies and programs should be developed to turn the forecasts into a *self-negating prophecy* (14:271). Forecasts of this nature will allow leadership to develop *proactive* rather than *reactive* policies and programs to address pilot retention.

Policy Implications for Management

The models produced by this research generally show either a leveling or decrease in retention for FY 90, followed by an increase in FY 91, then a decrease in FY 92 to a level lower than the rate traditionally enjoyed or desired. It is known that strong airline hiring will continue for at least the remainder of this decade, having a negative influence on retention. Thus, policies should be developed not only to attenuate the "siren" effect this hiring has on those who are already pilots, but to recruit those who will be less influenced by the siren's lure.

The Systems Perspective.

The author believes policies should be pursued that will take advantage of the interaction an open system must have with its environment in order to survive. The Air Force leader needs to be able to take the chaos presented to him in the form of poor pilot retention and diminished resources, and use them to his advantage. To illustrate, when a leader is handed "lemons," he should have the tools and flexibility at his disposal to make "lemonade."

"If It Ain't Broke, Don't Fix It."

The author has received input from some military sources who have suggested that lemonade *will* be made of the budget cut and pilot shortage lemons currently being served by the Air Force's environment. Theoretically, budget cuts could drive force levels so low as to make the pilot retention problem evaporate. Magically, retention would be at the level required. Changes in the personnel system would not be required since the problem would disappear. However, Peters believes in order for organizations to remain competitive, "if it ain't broke, you just haven't looked hard enough. Fix it anyway" (23:1). Today's lemons should not be viewed as lemons at all, but opportunities to make the far-reaching *proactive* changes tomorrow's Air Force requires.

Policy Ideas.

Often, it is an idea that is thought of as dumb or impractical that eventually yields the desired results (23:529-530). In the course of this research, several policy ideas occurred to the author that may be of some value to those who are poised to make the sweeping changes in the Air Force that are on the planning horizon. As the Air Force enters an era filled with uncertainty and chaos, "business as usual" will not likely suffice. The "dumb" ideas should be at least aired; the "dumb" questions should be asked.

Flexibility.

Flexibility is the key to airpower. The concept of flexibility is not foreign to any military leader when it comes to the strategy and tactics of warfare. Yet, when it comes to personnel management in the Air Force, flexibility has been eroded by attempts to, among other things, control pilot retention. Open systems are stable, while relatively closed systems are less so. Thus, as attempts are made to *control* retention by increasing ADSCs for UPT, permanent change of station (PCS) moves, and qualifying in a different aircraft, they may have the opposite effect than that intended: turnover rates could eventually *increase*. Incurring a ten year commitment for UPT graduation seems excessive and will possibly produce the opposite effect of that intended. While a ten-year ADSC will eradicate retention problems during an officer's first ten years of duty after UPT, when he eventually becomes eligible to leave, he may be more inclined to do so than if the ADSC had not been so lengthy.

The Peer Group Effect.

Of significance in this research is the discovery of the peer group effect discussed in chapter four. Assuming this effect among pilots does indeed exist, it follows that when the intent to quit is formulated by one pilot, it will in turn have an impact on the intents of his contemporaries. Thus, if a pilot's decision to leave the Air Force is made after having served five years, for example, he will have five more years to influence the intents of others who may not be so disposed.

General systems theory, when applied to the case of ADSCs, might follow a different path to turnover management. Rather than increase ADSCs for UPT, they might be reduced or eliminated altogether. A "no commitment for UPT" approach would increase the personnel system's interaction with the environment, and therefore move it towards stability. On the surface, this idea may sound silly, but it would reduce the impact of the peer group effect. Those not inclined to serve would leave when the decision is made, when they have less influence over their peers. Those who stay will have made their own decision to stay, having found their own reasons for reinforcing this decision. In so doing, the positive group norm that is required for healthy retention will theoretically evolve.

While reducing or eliminating ADSCs from UPT may decrease the negative effects of peer pressure, it will not reduce one's susceptibility to that pressure. The United States Air Force Academy (USAFA) supplies the bulk of UPT candidates in any given year. Among the many tools used to shape the behavior of these candidates while they are undergraduates is a peer rating system that is known as the *Leadership Attribute Survey*. This system currently allows each cadet to rate the lowest four cadets and the single top cadet in his squadron from his class and all classes below. The results are then briefed to each cadet individually by his Air Officer Commanding (AOC), with recommendations for improvement if poor marks are attained. Such a system tends to make the cadet more aware of what his peers think of him, or may think of him if he exhibits behavior that deviates from the norms of the group.

Other officer accession programs may have similar formal tools for "leveling" group norms. The author believes such devices may have the unintended effect of making each officer more susceptible to peer pressure. This may in turn help to explain the peer group effect. Since any group will inevitably establish norms, regardless of the formal system that exists to instill them, the author suggests that the greater good may be served by overhauling or eliminating the devices used by the Air Force to instill group norms in its training environments.

The Rated Supplement.

The assertion made in the first chapter that there can be functional turnover in the pilot career field, is only partially correct. Certainly, some turnover may occur that will not damage the Air Force's present war fighting capability. Yet, when dysfunctional turnover occurs (as it is presently), there are fewer pilots in the rated supplement to be drawn upon to sustain readiness, because turnover previously thought of as functional existed. Therefore, most pilot turnover contains an element of dysfunctionality. If more pilots were retained, regardless of the desired retention rate, more would be available to man cockpit vacancies created when retention dropped to unacceptable levels. Thus, we see the beauty and logic of a healthy rated supplement program.

Viewing some turnover as functional has another potential drawback: it creates a smaller pool of prospective leaders. The Air Force draws upon the rated force for the bulk of its senior leadership. Since the pool of potential leaders is reduced when functional turnover occurs, it may be seen as a limiting factor on the future availability of leadership resources.

Sabbatical.

Universities provide their professors with opportunities to take extended breaks from their official duties to pursue studies that will further their knowledge in their area of expertise. These breaks are known as sabbaticals. The author believes a similar opportunity should be extended to every career officer. Those who have achieved "career" status (for example, selection for promotion to Major or Lieutenant Colonel), should be afforded an opportunity to pursue an independent study program that will be responsible for nothing more than furthering the personal development and growth of the officer.

The sabbatical concept has two chief aspects that should positively influence retention. It provides an incentive for pilots to remain on active duty to reach the point where the sabbatical may be taken. It further motivates these officers by allowing them to develop their own personal development programs. In return, the service would most likely receive refreshed, more productive officers upon their resumption of active service.

Recruiting.

Since the service cannot recruit its senior military leadership from the civilian work force, the quality of the officer candidates recruited in any one year reflects directly upon the quality of its leadership years later. Therefore, recruiting the right personnel, while no easy task, is important.

> The task of transforming raw recruits into committed stars, able to cope with the pace of change that is becoming normal, begins with the recruiting process . . . . The best . . . insist that line people dominate the process . . . . (23:379)

Thus, Air Force leadership may wish to consider using flying squadron commanders actively in the recruiting process.

Other Ideas.

Other policies and programs that may have some positive effect on pilot retention might include:

•an airline job placement program for those pilots who have formally declared their intention to quit,

•a rating system for flying unit commanders that includes a measure of his unit's pilot retention rate,

•a retention program that is a continuous effort over the period of an officer's usefulness to the service,

•a recruiting program that emphasizes the philosophical aspects of military service, and,

•an assessment of the impact upon active duty pilot retention that the availability of Air National Guard and Air Force Reserve pilot positions may have.

The author recognizes that some of the ideas presented in this chapter may be viewed as being tainted with "ivory tower" idealism. However, if business as usual is the order of the day, even the best leadership may fail to positively impact pilot retention. As Warren Bennis wrote in *The Leadership Challenge,* reflecting on his time as President of the University of Cincinnati,

> My moment of truth came toward the end of my first ten months. It was one of those nights in the office. The clock was moving toward four in the morning, and I was still not through with the incredible mass of paper stacked before me. I was bone weary and soul weary, and I found myself muttering, "Either I can't manage this place, or it's unmanageable." I reached for my calendar and ran my eyes down each hour, half-hour, quarter-hour to see where my time had gone that

> day, the day before, the month before...My discovery was this: I had become a victim of a vast, amorphous, unwitting, unconscious conspiracy to prevent me from doing anything whatever to change the university's status quo. (23:497)

In the uncertain times ahead, maintaining the status quo is not likely to ensure that the Air Force can attract and retain the quality people it will require.

Recommendations for Model Improvement

When this research effort began, its original objective was to produce a model that could predict pilot retention not only by YOS but also by weapon system (the type of aircraft flown). As the author became embroiled in the model building effort, the research was scaled back to include only the former. Thus, these models may be improved by providing estimates of weapon system retention rates. The author's intent was to accomplish this by simply using historical probabilities. More accurate predictions might be obtained, however, through the use of a logit regression procedure.

Some of these models have parameters with significance levels greater than 0.1, which the reader may view as a cause for rejecting the variable from the model. In the models where the parameter significance grew over the three data set span that was used for testing and validation, other modelers may eventually wish to reject such variables. Since the retention rates for FY 90 will be known in October of this year, it is recommended that the models again be validated using these new rates.

The models produced by this methodology did not address multicollinearity per se, rendering sensitivity analysis impossible. To further the utility of these models, multicollinearity should be investigated. Since it is assumed to exist in some of the models, ridge regression techniques may be applicable as a remedial measure.

As discussed earlier in this chapter, the magnitude of the regression coefficients may be a useful analytical tool to some model users. To perform this analysis, the IVs for each model should be standardized. The regression for each model should be subsequently accomplished and the coefficients returned could then be analyzed for relative importance.

Recommendations for Further Research

Perhaps the most significant revelation this research produced was the effect that forecast retention rates of some year groups had on other year groups. This effect should be investigated further. It may exist across all year groups. A related research area would be to investigate the true causes of the peer group effect, if it does indeed exist.

The author recommends that multicollinearity be investigated, and remedial measures attempted, in the models where it is found to exist. These new models may then be revalidated using the FY 90 DV data that will be available in October 1990. New forecasts may then be made and compared to the forecasts produced in this research to assess the true impact that multicollinearity has on the predictive ability of the models. In addition, once remedial measures for multicollinearity have been taken, sensitivity analysis will then be possible.

A better method for introducing the error required for the alternate forecasting method may be available. This research used the *MathCAD* random number generator and an assumption that six standard deviations encompassed the total area under the normal curve. Perhaps there are existing methodologies that accomplish this error introduction in a more statistically valid manner.

Other variables may have better predictive ability of the DV than those used in this research. Besides the civilian aerospace sales variable that was discussed in chapter four, oil prices or aviation fuel prices may have some significant predictive ability. Suggested sources for other, possibly significant, variables are included in Appendix I.

Summary

A set of models that forecast pilot retention rates three years in advance, for year groups seven through fourteen, was constructed. Statistically significant economic variables were primarily used to build these models. Some models, however, required the use of peer group variables to adequately explain their DVs.

These models will supply Air Force leaders with the ability to anticipate retention rates 33 months in advance of when the actual rates become known. Armed with the forecasts of future rates, policies and programs may then be developed to mitigate any forecast rates that are deemed too low. Once these policies and programs have been implemented, their effectiveness should be evaluated through the use of actual retention data.

Appendix A: Data Sets

IV Data Sets

set	year	cut	form	acship	lfpart	lofac	sales
1	74	3735.2	1048.1	263	61.3	54.9	57.703
2	75	1544.7	608.77	285	61.2	53.7	48.904
3	76	2633.9	875.37	238	61.6	55.4	57.052
4	77	3271.9	1178.3	159	62.3	56.2	56.166
5	78	4671.7	1347.6	241	63.2	61.5	68.975
6	79	5718.8	1432.6	376	63.7	63	82.952
7	80	4533.3	1015.2	383	63.8	59	82.147
8	81	2370.2	762.77	388	63.9	58.6	77.34
9	82	1064	433	236	64	59	84.9
10	83	1108.8	524.54	262	64	60.7	88.162
11	84	1779	928.51	188	64.4	59.2	97.4
12	85	1670.9	608.66	273	64.8	61.4	100.09
13	86	1355.6	510.1	329	65.3	60.3	97.278
14	87	1232.8	566.7	261	65.6	62.3	101.19
15	88	2232.5	727.9	422	65.9	62.5	121.27
16	89	1564.5	658.75	445	66.5	63	117.24

set	year	nbf	netgrow	perc	gnp	comp
1	74	111	9.4	0.4484	54	0.977
2	75	108.8	10	0.4542	59.3	0.974
3	76	117.2	9.6	0.4508	63.1	0.954
4	77	130.8	10.4	0.4619	67.3	0.957
5	78	138.1	10.7	0.4658	72.2	0.939
6	79	138.3	11.5	0.4699	78.6	0.932
7	80	129.9	11.5	0.4758	85.7	0.954
8	81	124.8	10.3	0.4802	94	0.998
9	82	116.4	10	0.486	100	0.96
10	83	117.5	9.5	0.4906	103.9	0.946
11	84	121.3	9.5	0.4952	107.7	0.936
12	85	120.9	9.7	0.4996	110.9	0.923
13	86	120.4	9.6	0.5039	113.9	0.912
14	87	120.9	9.7	0.5074	117.7	0.899
15	88	124.1	9.8	0.5095	121.3	0.905
16	89	124.8	10.1	0.5121	126.3	0.896

DV Data Sets

set	year	7YOS	8YOS	9YOS	10YOS	11YOS	12YOS
1	77	0.848	0.9313	0.9513	0.9515	0.9684	0.9692
2	78	0.7505	0.8091	0.8718	0.9343	0.9487	0.9655
3	79	0.6374	0.6937	0.7717	0.8126	0.8733	0.893
4	80	0.6675	0.7992	0.8262	0.8976	0.9244	0.9187
5	81	0.7925	0.8418	0.89	0.9156	0.9585	0.9781
6	82	0.8521	0.9033	0.94	0.9591	0.9681	0.9728
7	83	0.8745	0.9429	0.9616	0.9782	0.9747	0.9841
8	84	0.8024	0.9018	0.9479	0.9632	0.9632	0.9674
9	85	0.7494	0.8143	0.8634	0.8782	0.9344	0.9564
10	86	0.7243	0.7918	0.8262	0.8475	0.8762	0.9365
11	87	0.6059	0.7237	0.7875	0.8597	0.8559	0.852
12	88	0.4702	0.63	0.7423	0.7756	0.8128	0.6702
13	89	0.407	0.4741	0.6374	0.6944	0.7911	0.5957

set	year	13YOS	14YOS
1	77	0.9743	0.9867
2	78	0.9745	0.9758
3	79	0.9469	0.9737
4	80	0.9522	0.9749
5	81	0.9808	0.9875
6	82	0.9895	0.9948
7	83	0.9617	0.9915
8	84	0.9573	0.9929
9	85	0.955	0.9864
10	86	0.9864	0.9816
11	87	0.967	0.972
12	88	0.9413	0.9603
13	89	0.9014	0.9315

Appendix B: Major Airline Pilot Retirements, 1988 - 2025

year	total	
1988	481	
1989	519	
1990	727	
1991	798	
1992	1042	
1993	1144	
1994	1361	
1995	1362	
1996	1501	
1997	1575	
1998	1791	
1999	1893	
	13194	total, 1990 - 1999
2000	1882	
2001	1759	
2002	1835	
2003	1536	
2004	1206	
2005	1228	
2006	1304	
2007	1577	
2008	1608	
2009	1643	
2010	1556	
2011	1327	
2012	1257	
2013	1146	
2014	1127	
2015	1072	
2016	1075	
2017	909	
2018	691	
2019	511	
2020	443	
2021	331	
2022	178	
2023	84	
2024	38	
2025	9	
	54720	total, 1988 - 2025

Appendix C: Regression Coefficients

Model/Variable	Coefficients set 12	set 13
7YOS		
cut	0.000246	0.00025
lofac	0.086808	0.088382
nbf	-0.04084	-0.04088
netgrow	0.30373	0.30171
8YOS		
cut	0.000263	0.000258
nbf	-0.01921	-0.01853
gnp	-0.01111	-0.010836
comp	9.6071	9.7545
trate7	0.82341	0.83905
9YOS		
cut	0.000588	0.000588
nbf	-0.05374	-0.05275
netgrow	0.28625	0.28679
perc	27.234	26.761
comp	22.533	23.275
10YOS		
cut	0.000456	0.000456
nbf	-0.05027	-0.04929
netgrow	0.58347	0.58399
perc	20.939	20.473
comp	21.676	22.407
11YOS		
lfpart	1.6548	1.076
gnp	-0.10384	-0.07108
comp	15.113	17.585
nbf	-0.05335	-0.03348
netgrow	0.37535	0.4904
12YOS "A"		
tratell	1.201	1.308
12YOS "B"		
tratell	1.0653	1.0212
trate14	0.18846	0.35044
12YOS "C"		
lfpart	-1.0194	-0.9906
gnp	0.050127	0.048751
lofac	0.15224	0.14814
tratell	1.4618	1.4518

Model/Variable	Coefficients set 12	set 13
13YOS		
lfpart	-2.5602	-2.0371
lofac	0.31756	0.28397
perc	146.39	114.41
mttot	0.000167	0.000136
trate14	0.8462	0.60085
14YOS		
cut	0.000226	0.000245
lofac	0.17207	0.17912
nbf	-0.03054	-0.03071
netgrow	0.30008	0.29102
comp	21.731	24.406

Appendix D: Model R^2, R_a^2, P, T, and Approximate Wilk-Shapiro Values

Model

	Set	7YOS	8YOS	9YOS	10YOS	11YOS
	11	0.942	0.9628	0.9764	0.9663	0.9752
R-squared	12	0.8949	0.9685	0.9748	0.9625	0.9413
	13	0.9202	0.9761	0.978	0.969	0.9193
	11	0.884	0.9257	0.9528	0.9266	0.9504
Adjusted	12	0.8073	0.9423	0.9537	0.9313	0.8979
R-squared	13	0.8632	0.959	0.9622	0.9469	0.8617
	11	0.0041	0.0014	0.0005	0.0013	0.0005
Model "P"	12	0.0067	0.0002	0.0001	0.0003	0.0011
	13	0.001	0.0	0.0	0.0	0.0011
	11	8	7	6	8	6
T	12	8	7	8	9	8
	12	8	8	6	8	6
	11	0.9394	0.9842	0.9705	0.9644	0.9414
Approximate	12	0.8959	0.9849	0.9363	0.9614	0.938
Wilk-Shapiro	13	0.9349	0.9798	0.9418	0.9615	0.9682

	Set	12YOS"A"	12YOS"B"	12YOS"C"	13YOS	14YOS
	11	0.8604	0.8631	0.8692	0.9759	0.9839
R-squared	12	0.8701	0.8747	0.9102	0.93	0.9333
	13	0.8881	0.9014	0.9385	0.9081	0.9408
	11	0.8448	0.8239	0.782	0.9519	0.9679
Adjusted	12	0.8571	0.8468	0.8588	0.8717	0.8776
R-squared	13	0.878	0.8816	0.9078	0.8424	0.8985
	11	0.0	0.0004	0.0081	0.0005	0.0002
Model "P"	12	0.0	0.0001	0.0009	0.0021	0.0018
	13	0.0	0.0	0.0001	0.0016	0.0004
	11	9	9	9	6	7
T	12	9	9	7	9	7
	13	7	9	7	8	5
	11	0.9483	0.91	0.9672	0.9649	0.9607
Approximate	12	0.9775	0.9841	0.9423	0.9663	0.9304
Wilk-Shapiro	13	0.9644	0.9564	0.9458	0.9229	0.9356

Appendix E: Model Forecasts

		7YOS			8YOS	
year	rate	forecast	alternate	rate	forecast	alternate
77	0.848	0.8414	0.8408	0.9313	0.9258	0.9269
78	0.7505	0.7579	0.7531	0.8091	0.8142	0.8169
79	0.6374	0.6746	0.6772	0.6937	0.7382	0.7375
80	0.6675	0.6591	0.65	0.7992	0.7535	0.7591
81	0.7925	0.7678	0.7731	0.8418	0.8505	0.8497
82	0.8521	0.865	0.8708	0.9033	0.9141	0.9118
83	0.8745	0.8611	0.8611	0.9429	0.9352	0.9345
84	0.8024	0.8347	0.825	0.9018	0.9102	0.9152
85	0.7494	0.7215	0.7252	0.8143	0.8208	0.8173
86	0.7243	0.6557	0.6708	0.7918	0.7846	0.7754
87	0.6059	0.5589	0.5776	0.7237	0.7224	0.7079
88	0.4702	0.5927	0.6223	0.63	0.6015	0.5721
89	0.407	0.4359	0.4809	0.4741	0.4926	0.4448
90		0.431	0.4913		0.4436	0.3771
91		0.5539	0.5974		0.6628	0.6254
92		0.4685	0.5241		0.5136	0.4528

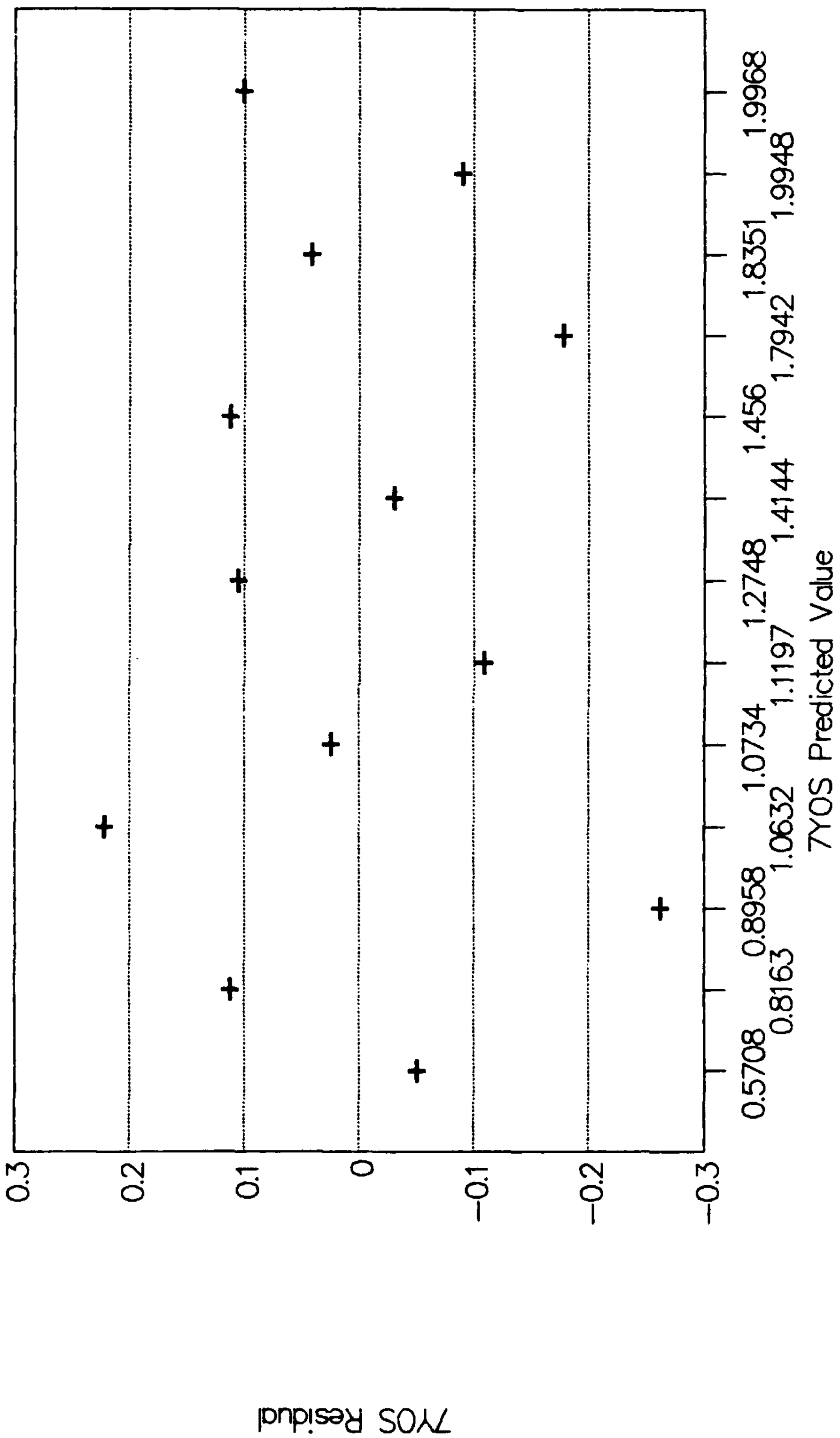
		9YOS			10YOS	
77	0.9513	0.9494	0.9491	0.9515	0.9522	0.9511
78	0.8718	0.8721	0.876	0.9343	0.9214	0.9209
79	0.7717	0.7939	0.7967	0.8126	0.8455	0.8455
80	0.8262	0.8404	0.8451	0.8976	0.8949	0.8928
81	0.89	0.8707	0.8704	0.9156	0.9078	0.9078
82	0.94	0.9413	0.9394	0.9591	0.9616	0.9626
83	0.9616	0.9617	0.9609	0.9782	0.9768	0.9772
84	0.9479	0.9528	0.9545	0.9632	0.9664	0.9643
85	0.8634	0.85	0.8489	0.8782	0.8982	0.9002
86	0.8262	0.7807	0.7735	0.8475	0.8235	0.8301
87	0.7875	0.7985	0.7872	0.8597	0.8215	0.8301
88	0.7423	0.761	0.7434	0.7756	0.7998	0.8147
89	0.6374	0.6673	0.6379	0.6944	0.7193	0.7453
90		0.5606	0.5154		0.6427	0.6831
91		0.7695	0.743		0.7908	0.8122
92		0.6256	0.5856		0.7138	0.7472

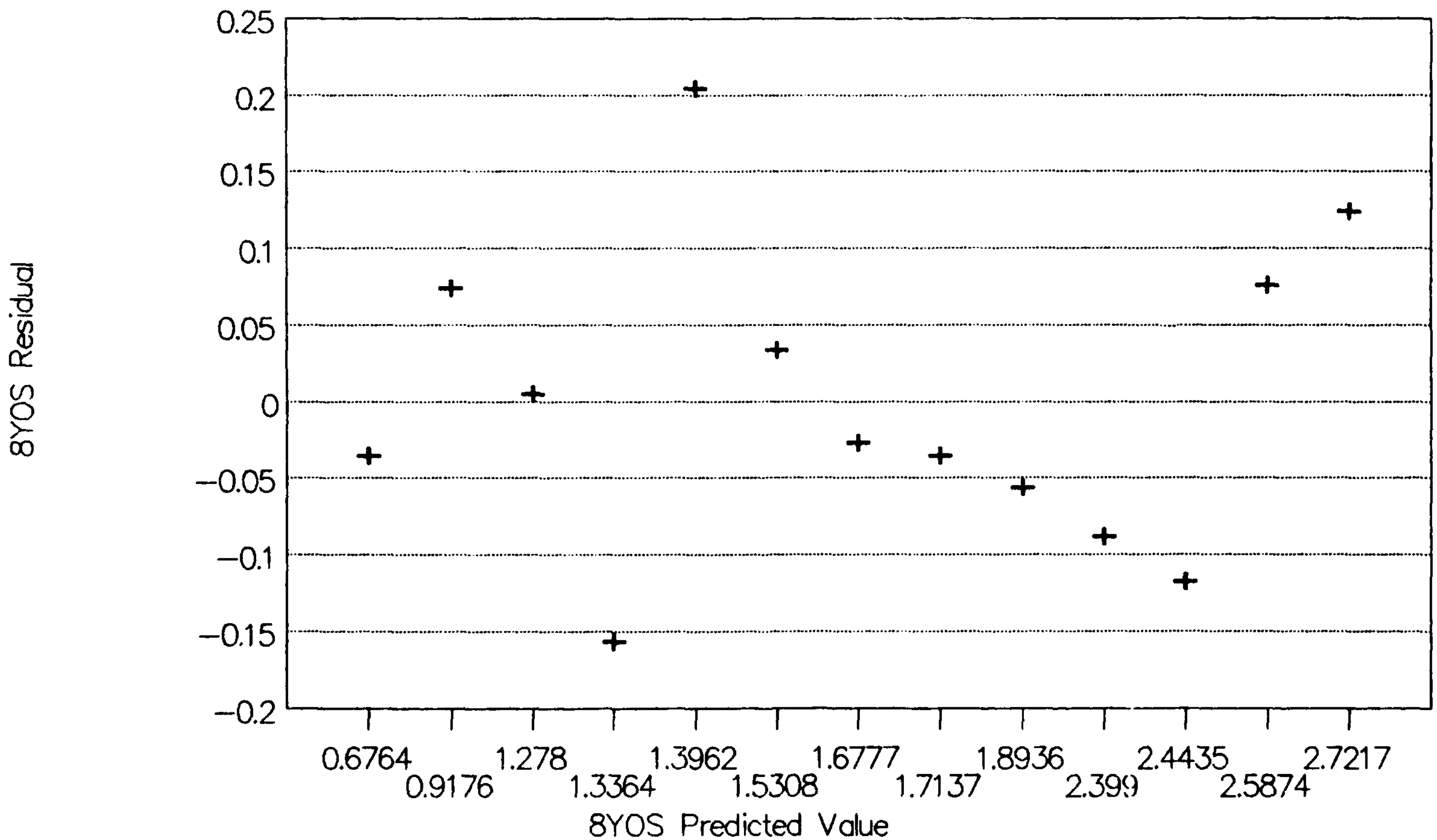
	11YOS			12YOS "A"		
year	rate	forecast	alternate	rate	forecast	alternate
77	0.9684	0.9592	0.9567	0.9692	0.9784	0.9786
78	0.9487	0.9515	0.9558	0.9655	0.9591	0.9583
79	0.8733	0.9043	0.91	0.893	0.8662	0.8556
80	0.9244	0.939	0.9491	0.9187	0.9319	0.9291
81	0.9585	0.9506	0.9478	0.9781	0.969	0.9688
82	0.9681	0.9653	0.9628	0.9728	0.9781	0.9783
83	0.9747	0.9738	0.9732	0.9841	0.9839	0.9843
84	0.9632	0.9701	0.9715	0.9674	0.9736	0.9736
85	0.9344	0.9285	0.9248	0.9564	0.9435	0.9416
86	0.8762	0.8388	0.8366	0.9365	0.8701	0.8611
87	0.8559	0.8139	0.8032	0.852	0.8416	0.8292
88	0.8128	0.8293	0.8013	0.6702	0.7771	0.756
89	0.7911	0.8455	0.7903	0.5957	0.7428	0.7167
90		0.8214	0.7471		0.7904	0.7712
91		0.8408	0.7781		0.8196	0.8043
92		0.8769	0.809		0.8712	0.8622

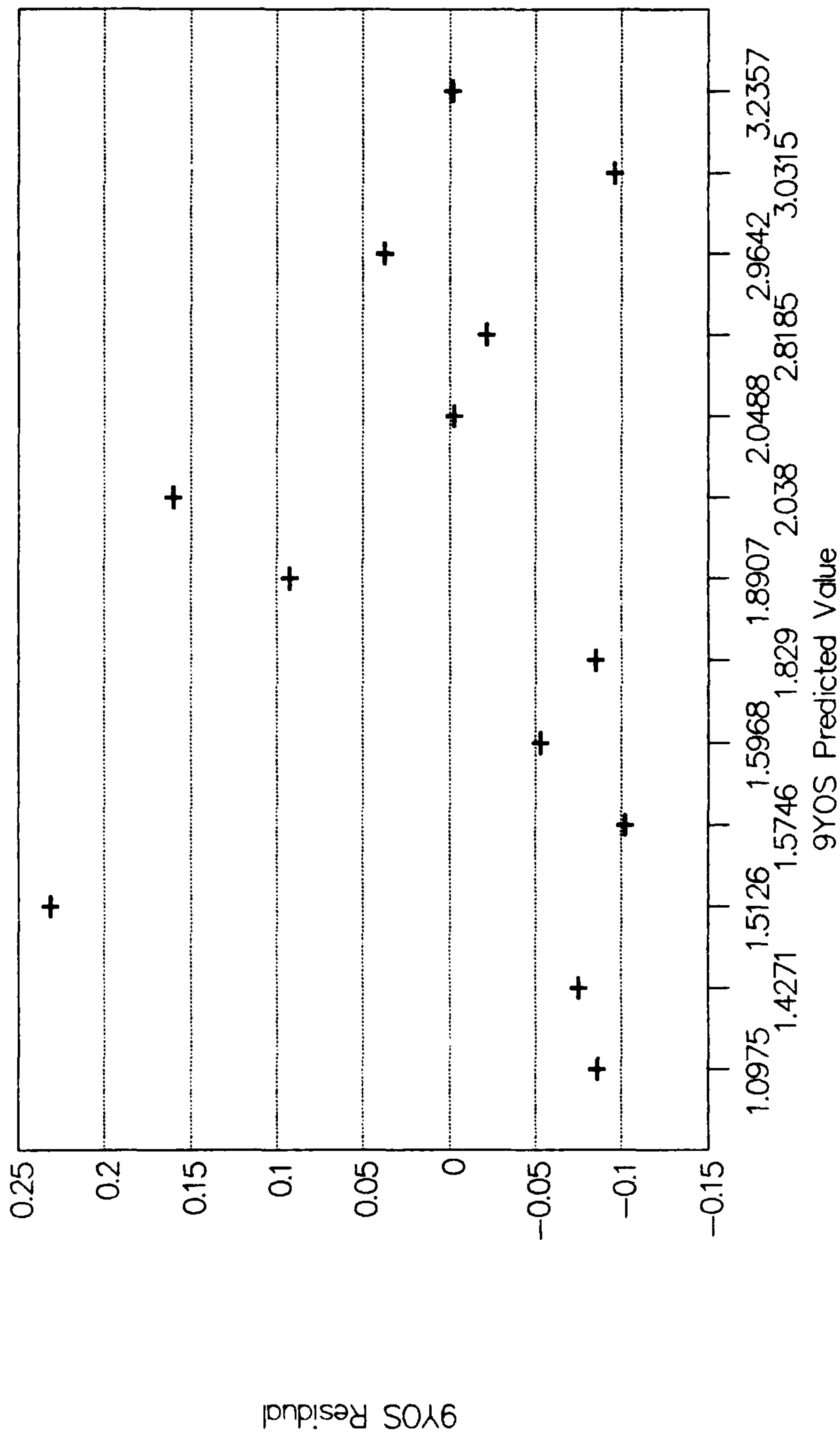
	12YOS "B"			12YOS "C"		
77	0.9692	0.9754	0.9758	0.9692	0.9794	0.9803
78	0.9655	0.9504	0.9502	0.9655	0.9651	0.967
79	0.893	0.8715	0.8624	0.893	0.8752	0.8783
80	0.9187	0.9253	0.9229	0.9187	0.9143	0.9125
81	0.9781	0.9681	0.9679	0.9781	0.9687	0.9683
82	0.9728	0.9817	0.9816	0.9728	0.9796	0.9793
83	0.9841	0.9832	0.9836	0.9841	0.9791	0.9781
84	0.9674	0.9766	0.9764	0.9674	0.9721	0.9712
85	0.9564	0.9475	0.9455	0.9564	0.9499	0.949
86	0.9365	0.8888	0.88	0.9365	0.9192	0.9205
87	0.852	0.8503	0.8384	0.852	0.844	0.8367
88	0.6702	0.7795	0.7595	0.6702	0.7907	0.7794
89	0.5957	0.7025	0.6774	0.5957	0.59	0.5352
90		0.7677	0.7493		0.7284	0.6976
91		0.8178	0.8033		0.7478	0.7151
92		0.8482	0.8402		0.7707	0.7306

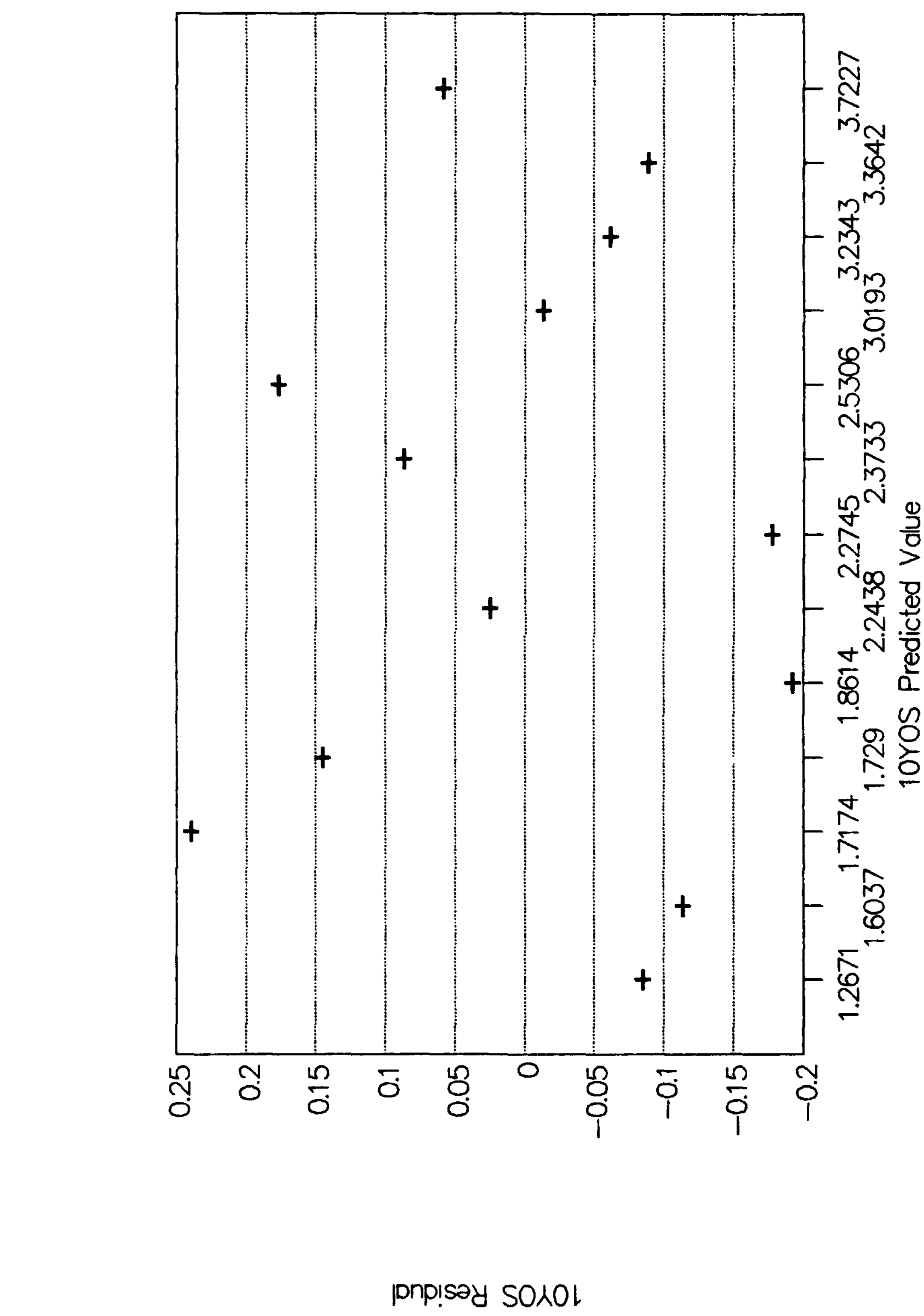
		13YOS			14YOS	
year	rate	forecast	alternate	rate	forecast	alternate
77	0.9743	0.9759	0.9747	0.9867	0.9877	0.9886
78	0.9745	0.971	0.97	0.9758	0.9772	0.9764
79	0.9469	0.9472	0.9484	0.9737	0.9692	0.9693
80	0.9522	0.9581	0.9581	0.9749	0.9747	0.975
81	0.9808	0.9803	0.9809	0.9875	0.9881	0.9885
82	0.9895	0.9883	0.9883	0.9948	0.9938	0.9938
83	0.9617	0.9619	0.9616	0.9915	0.9921	0.992
84	0.9573	0.96	0.96	0.9929	0.9943	0.9946
85	0.955	0.9595	0.9606	0.9864	0.9826	0.9818
86	0.9864	0.9834	0.9837	0.9816	0.9784	0.9777
87	0.967	0.9615	0.9622	0.972	0.9651	0.9641
88	0.9413	0.9635	0.9657	0.9603	0.9691	0.9673
89	0.9014	0.874	0.887	0.9315	0.9454	0.9408
90		0.9242	0.9323		0.9468	0.9409
91		0.9285	0.9348		0.9631	0.9605
92		0.7999	0.8291		0.9534	0.9478

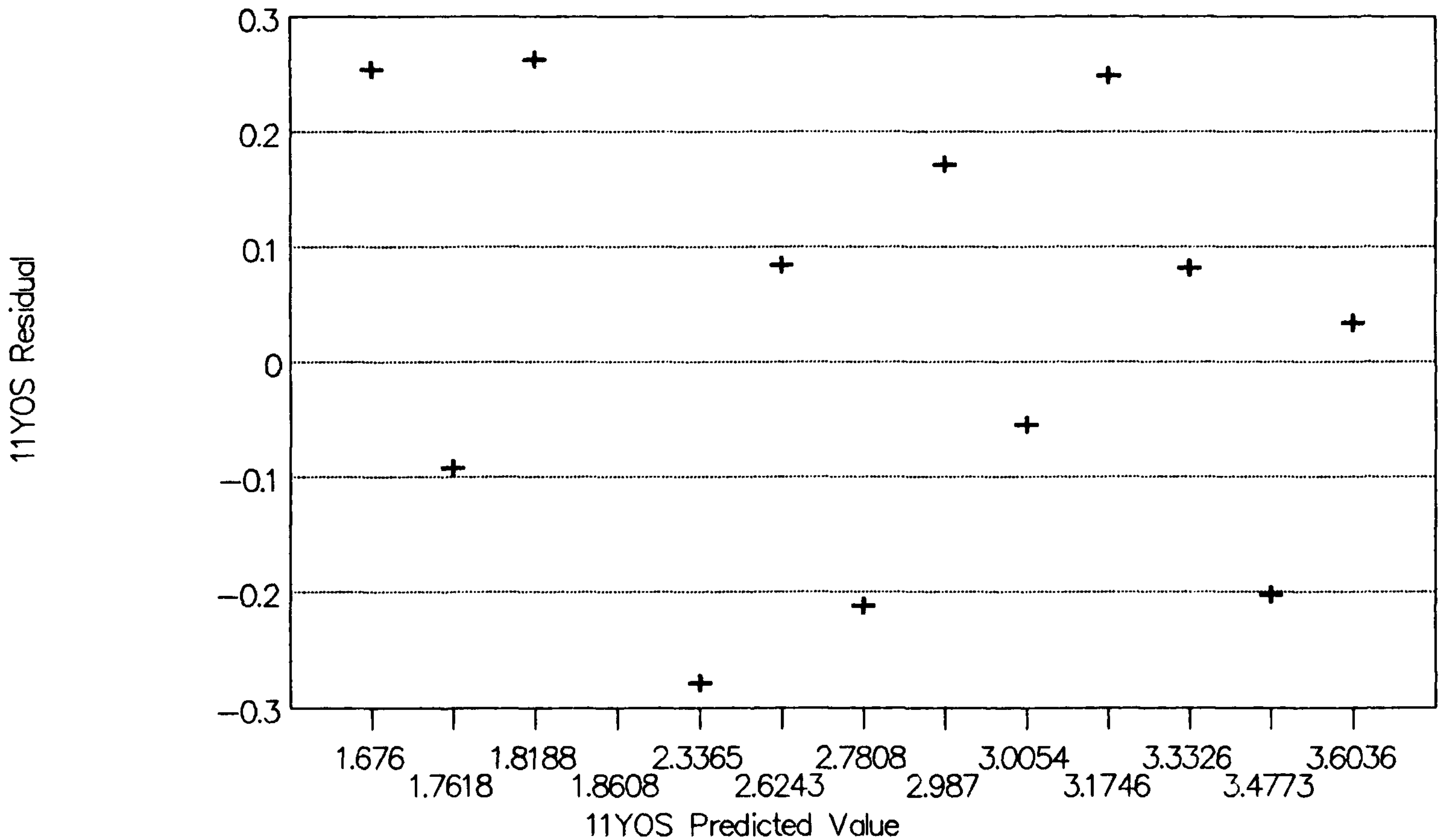
Appendix F: Graphs of Residuals vs. Predicted Values

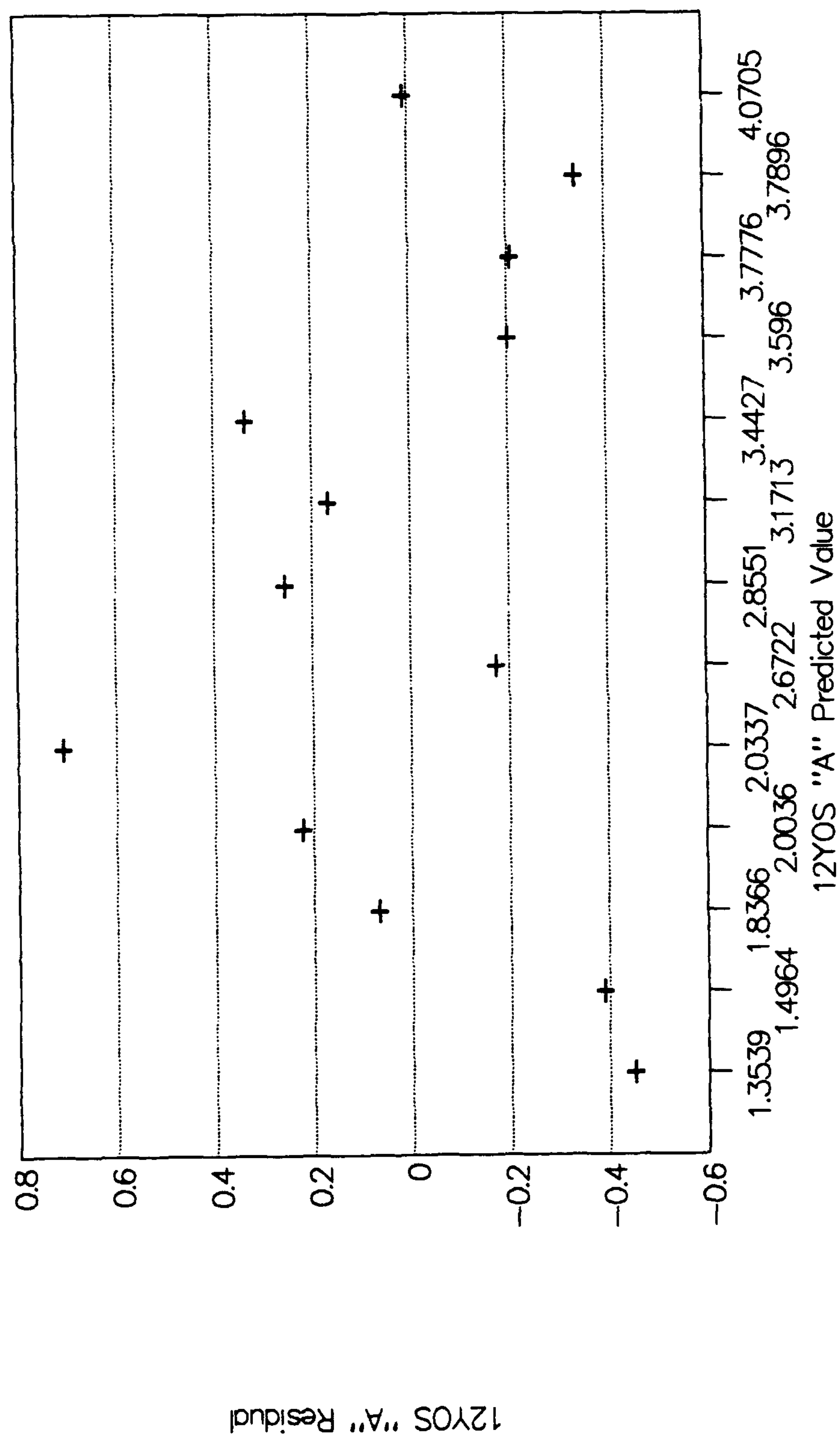



8YOS Residual
0.25
0.2
0.15
0.1
0.05
0
−0.05
−0.1
−0.15
−0.2
0.6764
0.9176
1.278
1.3364
1.3962
1.5308
1.6777
1.7137
1.8936
2.399
2.4435
2.5874
2.7217
8YOS Predicted Value

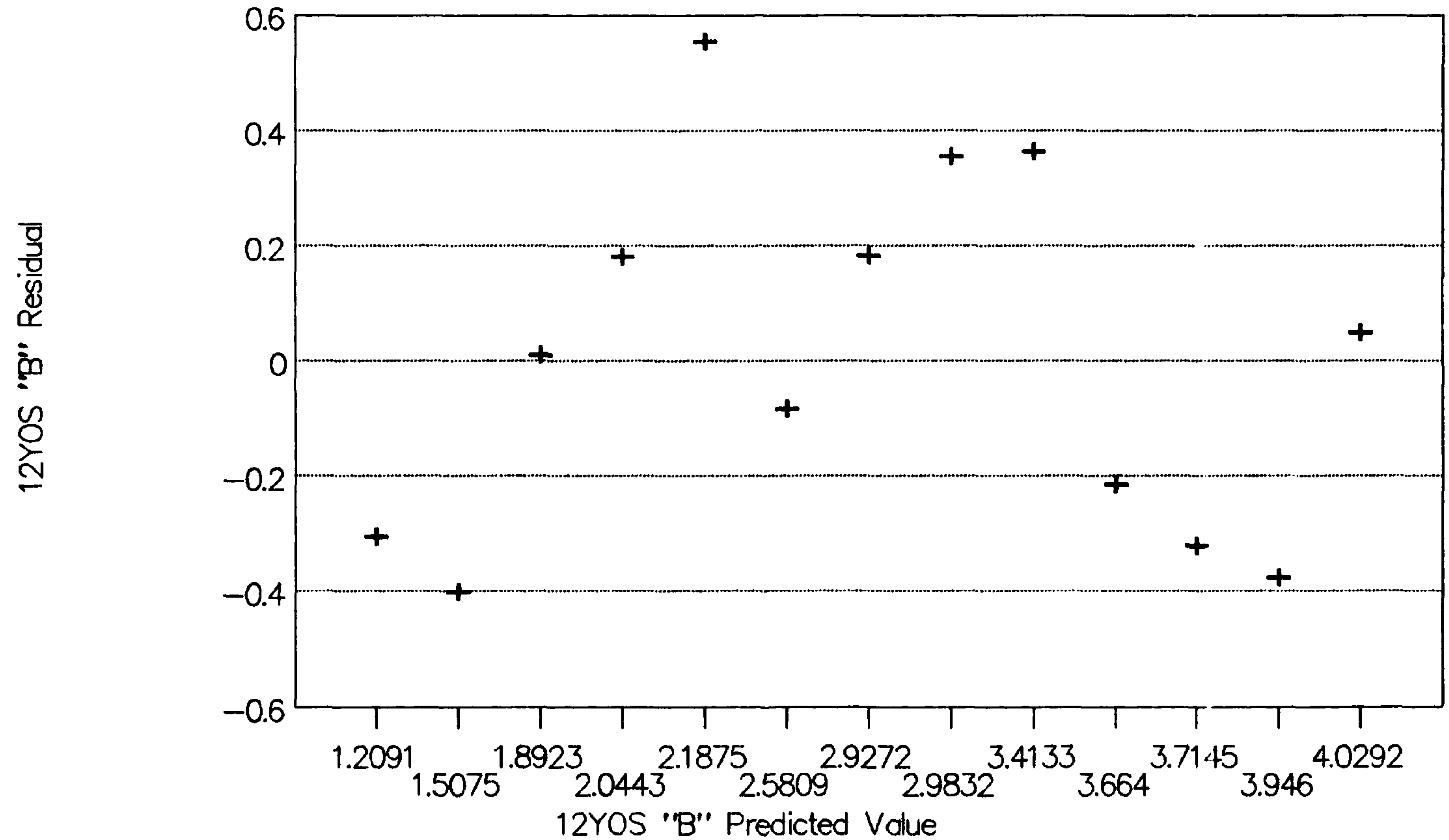

9YOS Predicted Value
9YOS Residual
1.0975
1.4271
1.5126
1.5746
1.5968
1.829
1.8907
2.038
2.0488
2.8185
2.9642
3.0315
3.2357
0.25
0.2
0.15
0.1
0.05
0
−0.05
−0.1
−0.15

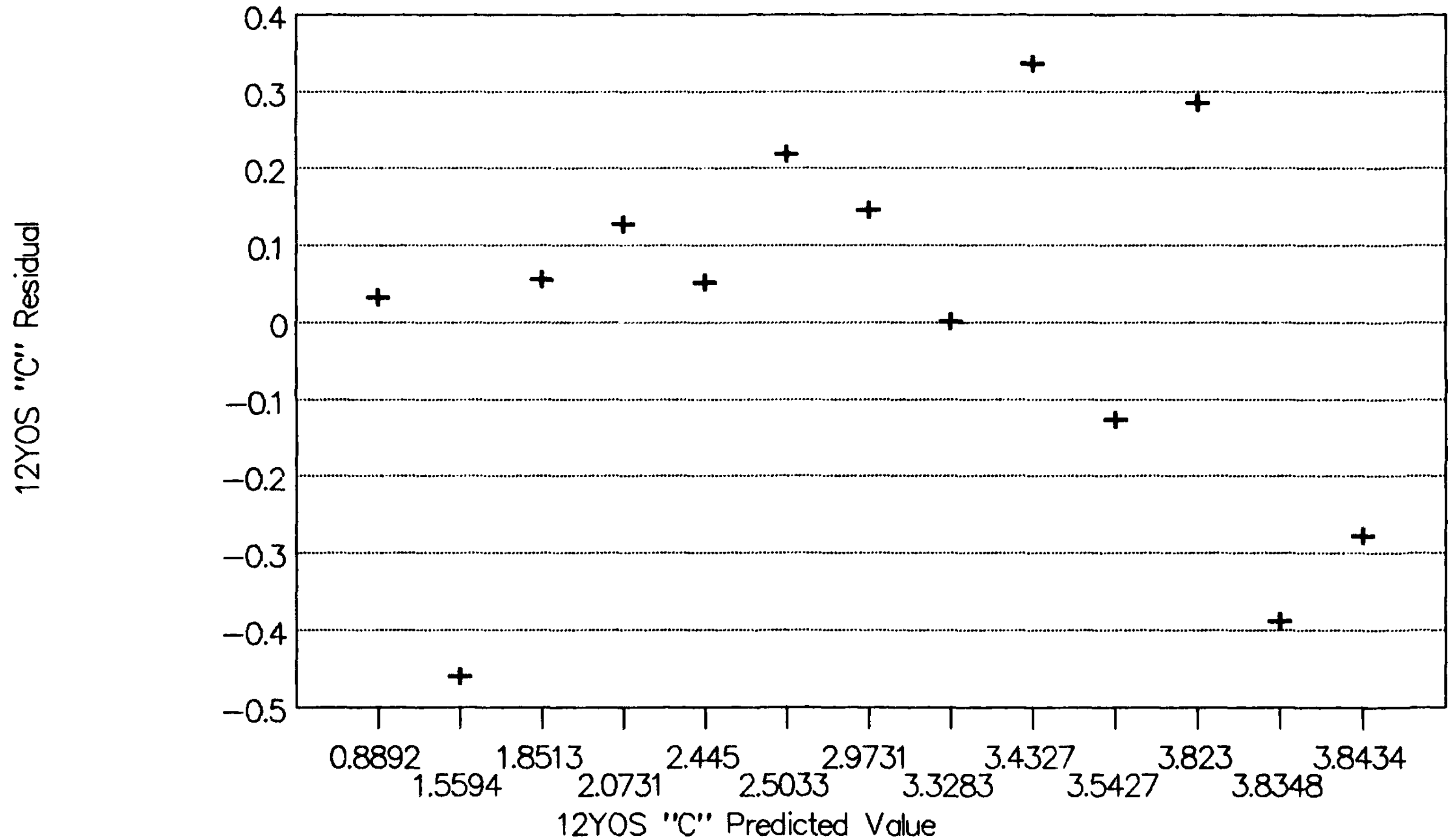

0.25
0.2
0.15
0.1
0.05
0
−0.05
−0.1
−0.15
−0.2
10YOS Residual
1.2671
1.6037
1.7174
1.729
1.8614
2.2438
2.2745
2.3733
2.5306
3.0193
3.2343
3.3642
3.7227
10YOS Predicted Value

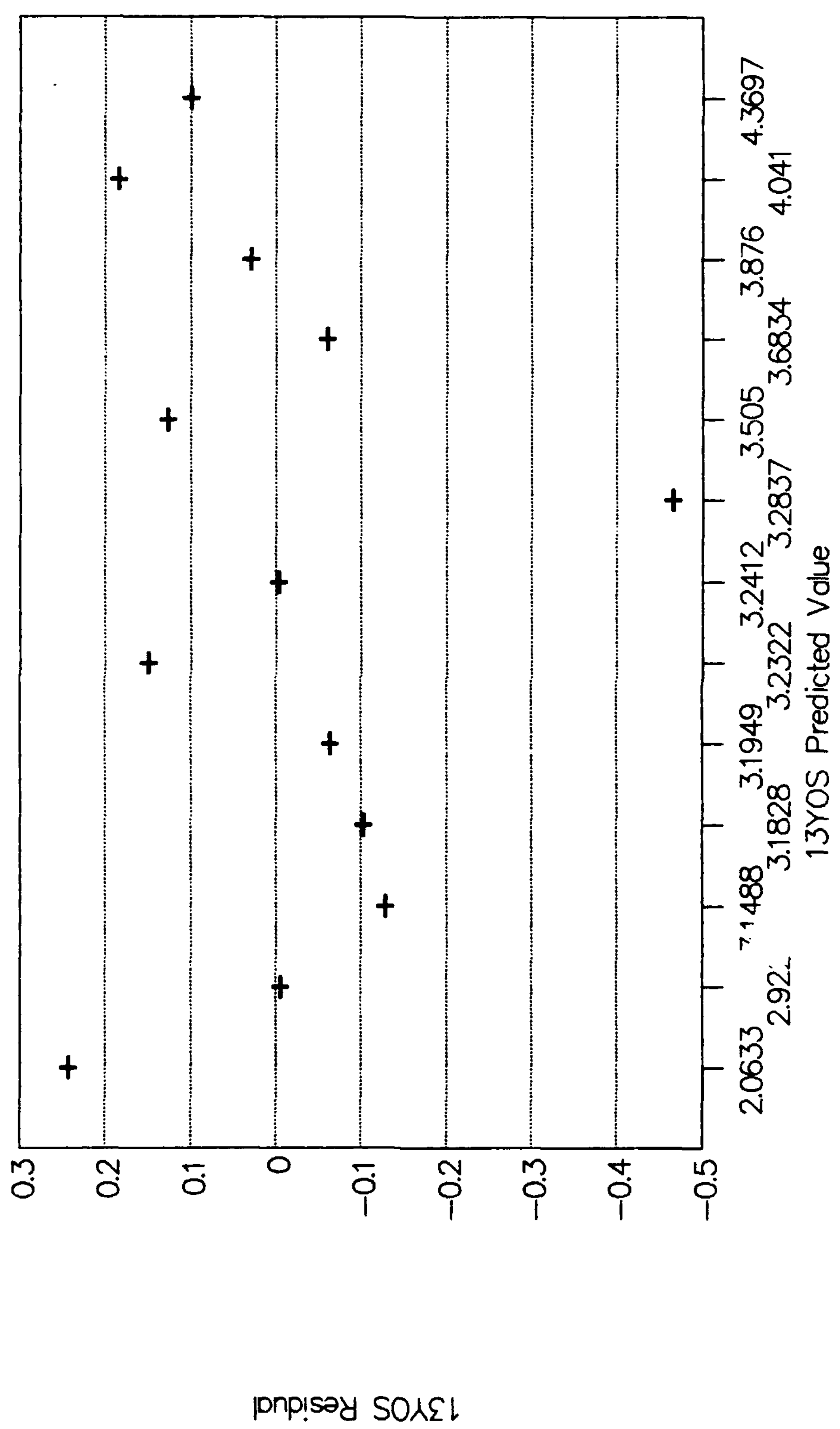

0.3
0.2
0.1
0
−0.1
−0.2
−0.3
11YOS Residual
1.676
1.7618
1.8188
1.8608
2.3365
2.6243
2.7808
2.987
3.0054
3.1746
3.3326
3.4773
3.6036
11YOS Predicted Value

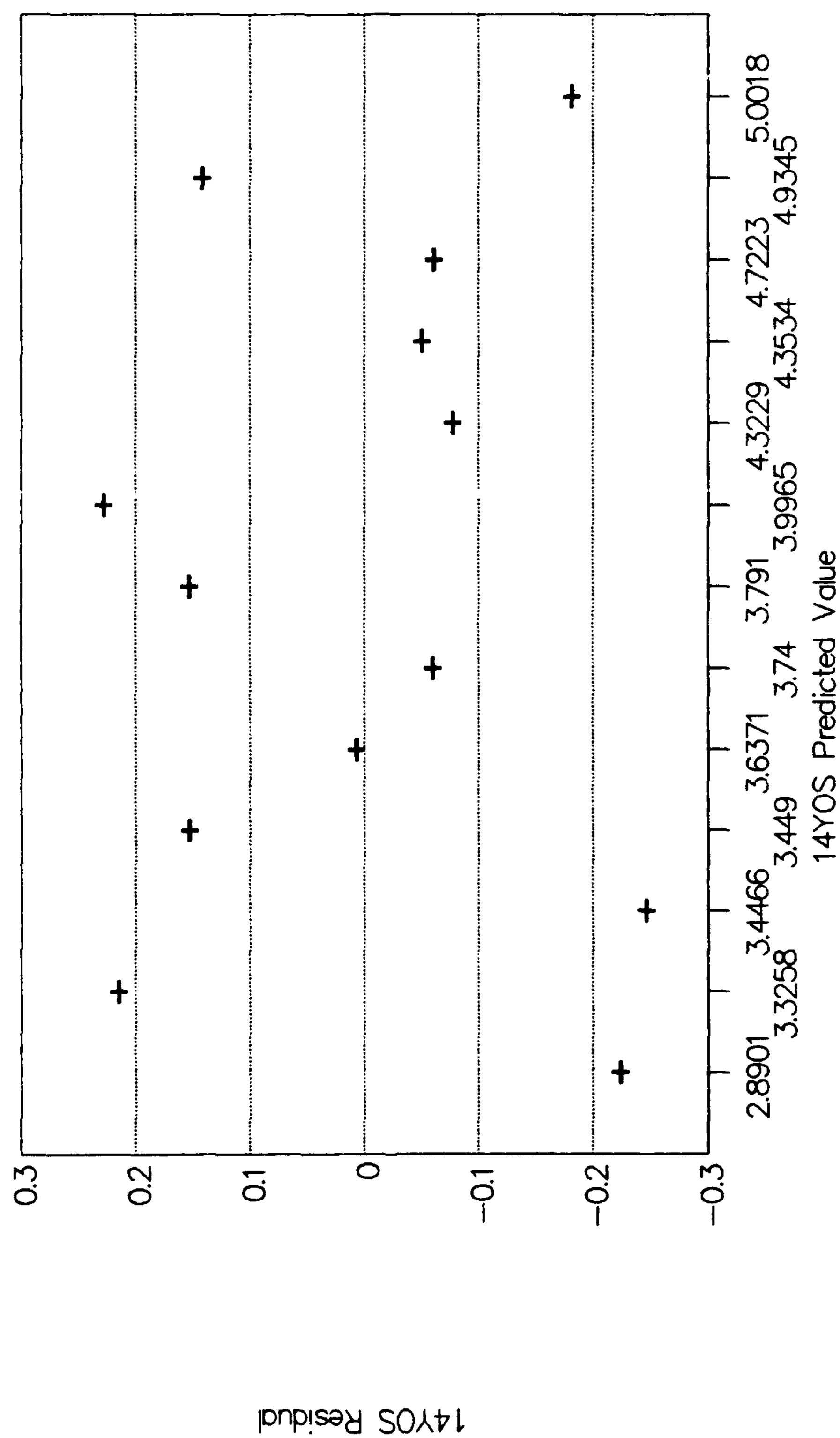


12YOS "A" Residual
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
1.3539
1.4964
1.8366
2.0036
2.0337
2.6722
2.8551
3.1713
3.4427
3.596
3.7776
3.7896
4.0705
12YOS "A" Predicted Value

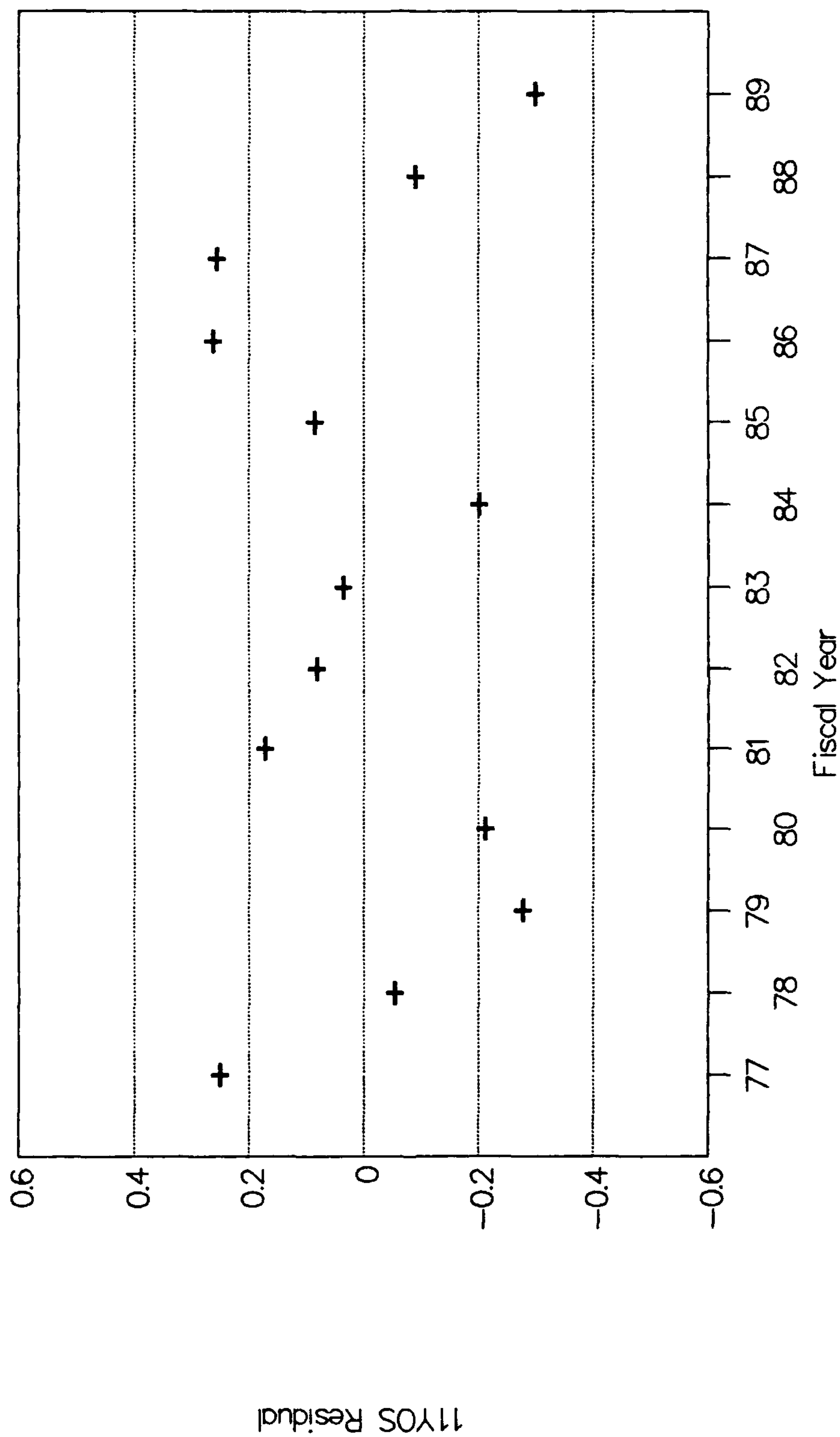

12YOS "B" Residual
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
1.2091
1.5075
1.8923
2.0443
2.1875
2.5809
2.9272
2.9832
3.4133
3.664
3.7145
3.946
4.0292
12YOS "B" Predicted Value

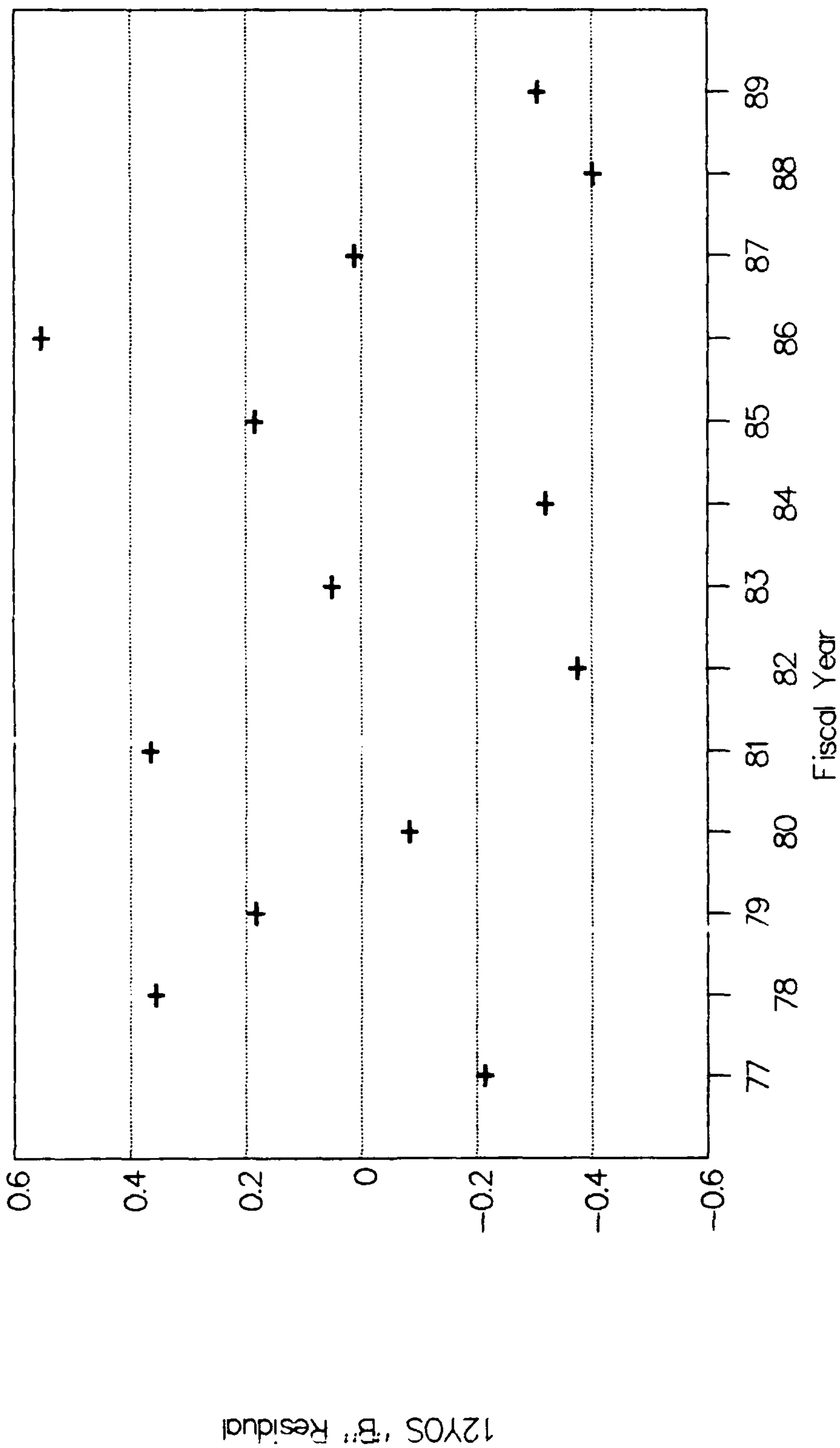

0.4
0.3
0.2
0.1
0
−0.1
−0.2
−0.3
−0.4
−0.5
12YOS "C" Residual
0.8892
1.5594
1.8513
2.0731
2.445
2.5033
2.9731
3.3283
3.4327
3.5427
3.823
3.8348
3.8434
12YOS "C" Predicted Value

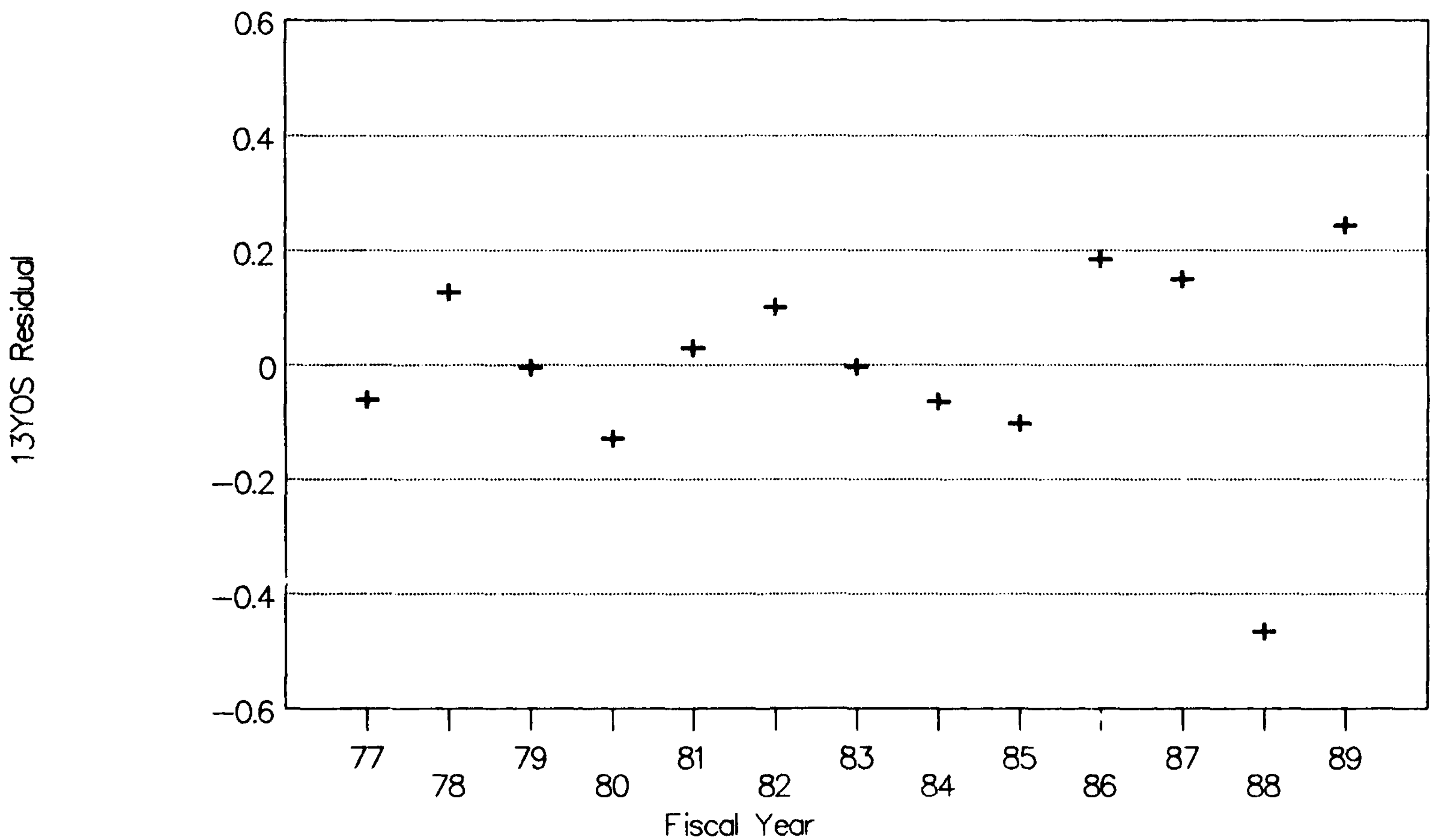

13YOS Residual
0.3
0.2
0.1
0
−0.1
−0.2
−0.3
−0.4
−0.5
2.0633
3.1828
3.1949
3.2322
3.2412
3.2837
3.505
3.6834
3.876
4.041
4.3697
13YOS Predicted Value


14YOS Residual
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
2.8901
3.3258
3.4466
3.449
3.6371
3.74
3.791
3.9965
4.3229
4.3534
4.7223
4.9345
5.0018
14YOS Predicted Value

Appendix G: Graphs of Residuals vs. Time

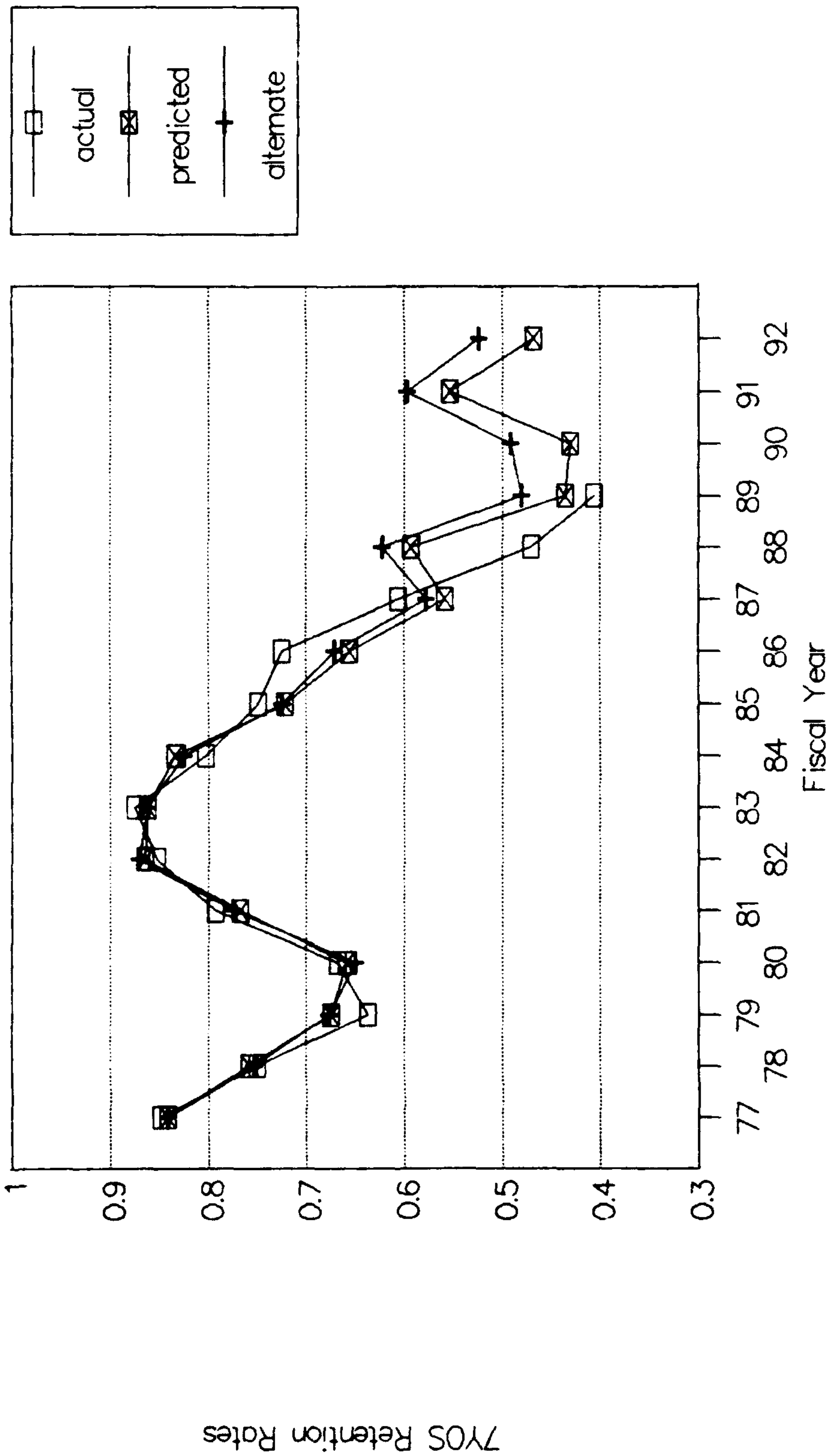


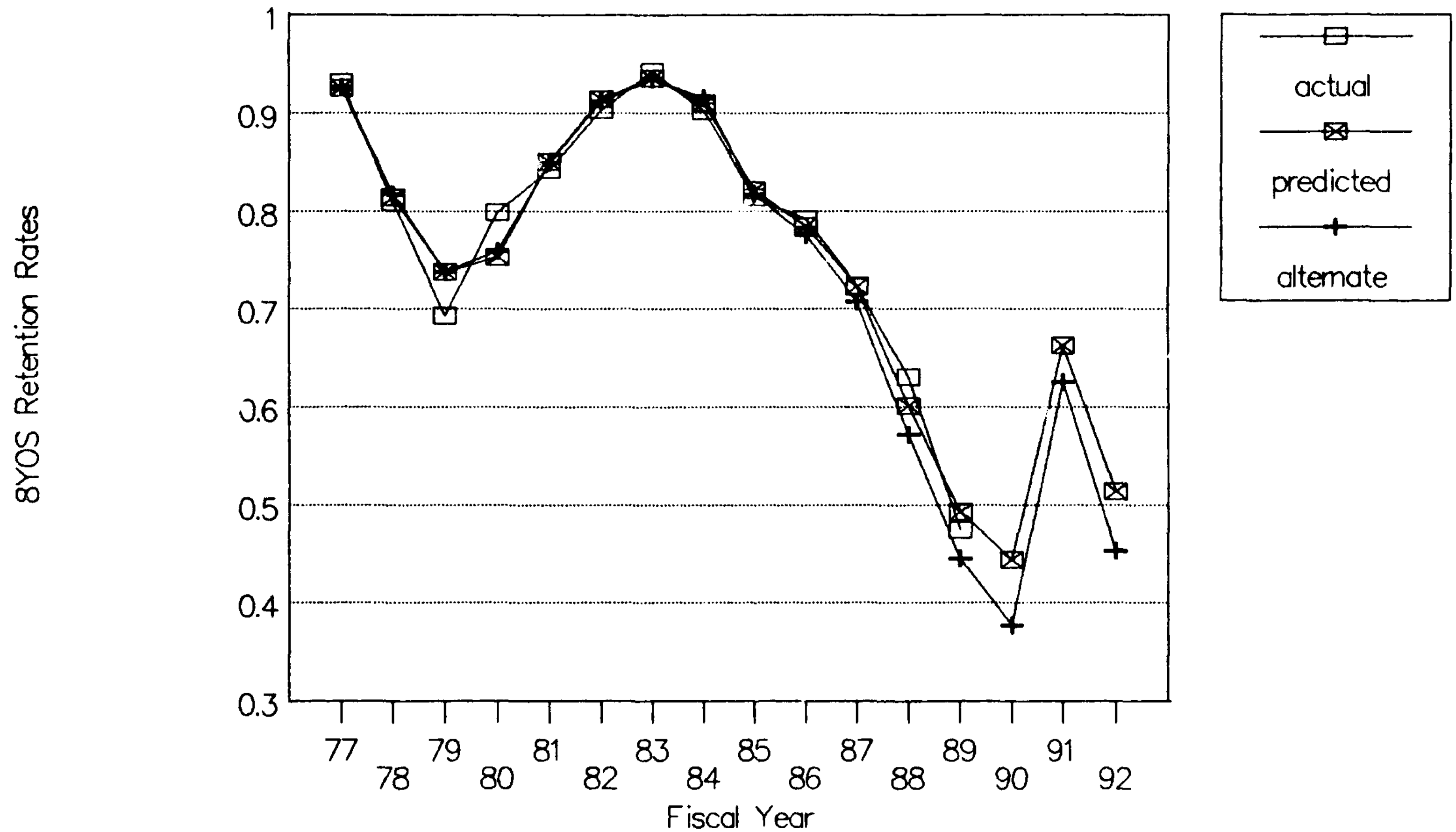

0.6
0.4
0.2
0
-0.2
-0.4
-0.6
12YOS 'B' Residual
77
78
79
80
81
82
83
84
85
86
87
88
89
Fiscal Year



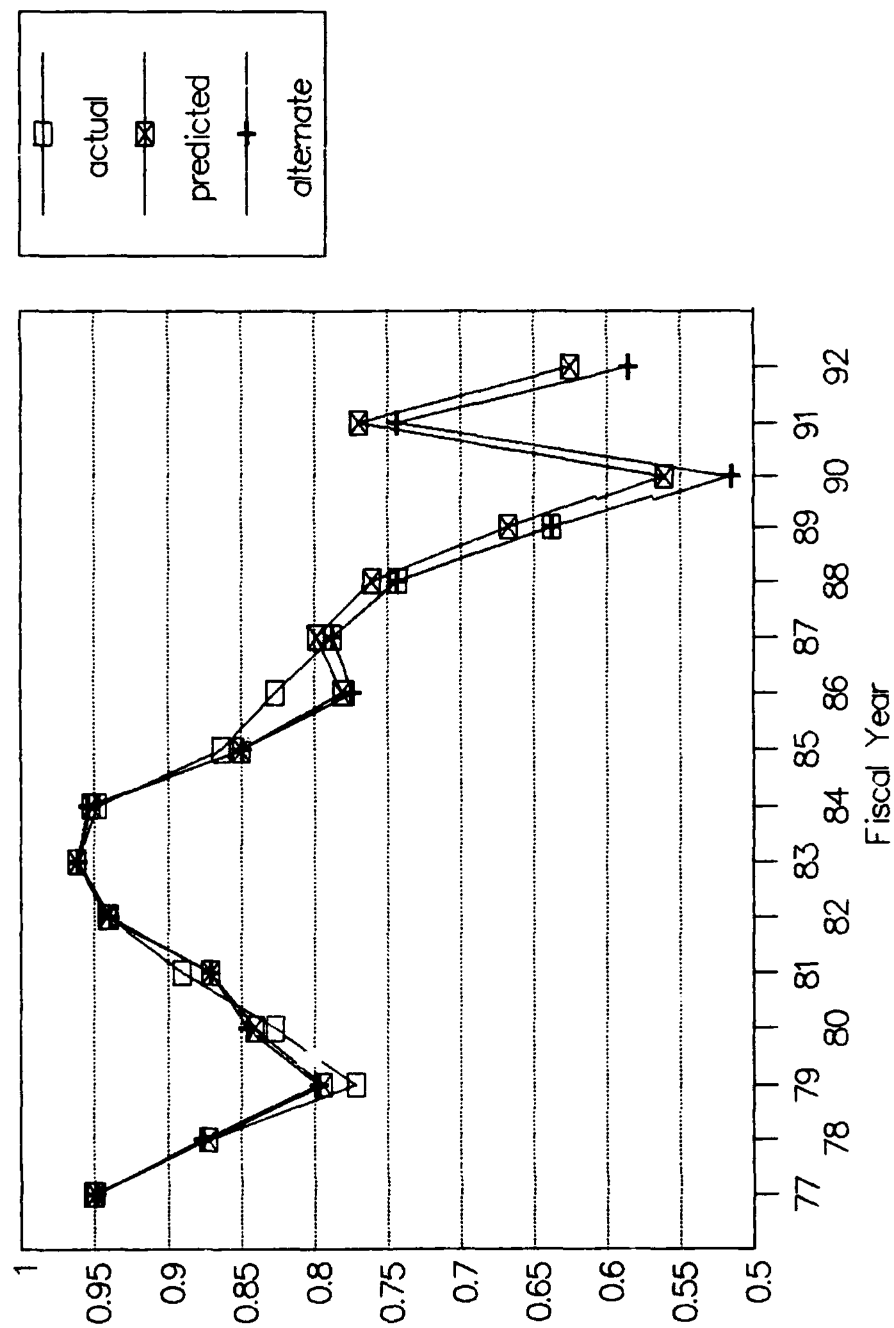
13YOS Residual
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
77
78
79
80
81
82
83
84
85
86
87
88
89
Fiscal Year

Appendix H: Graphs of Model Forecasts

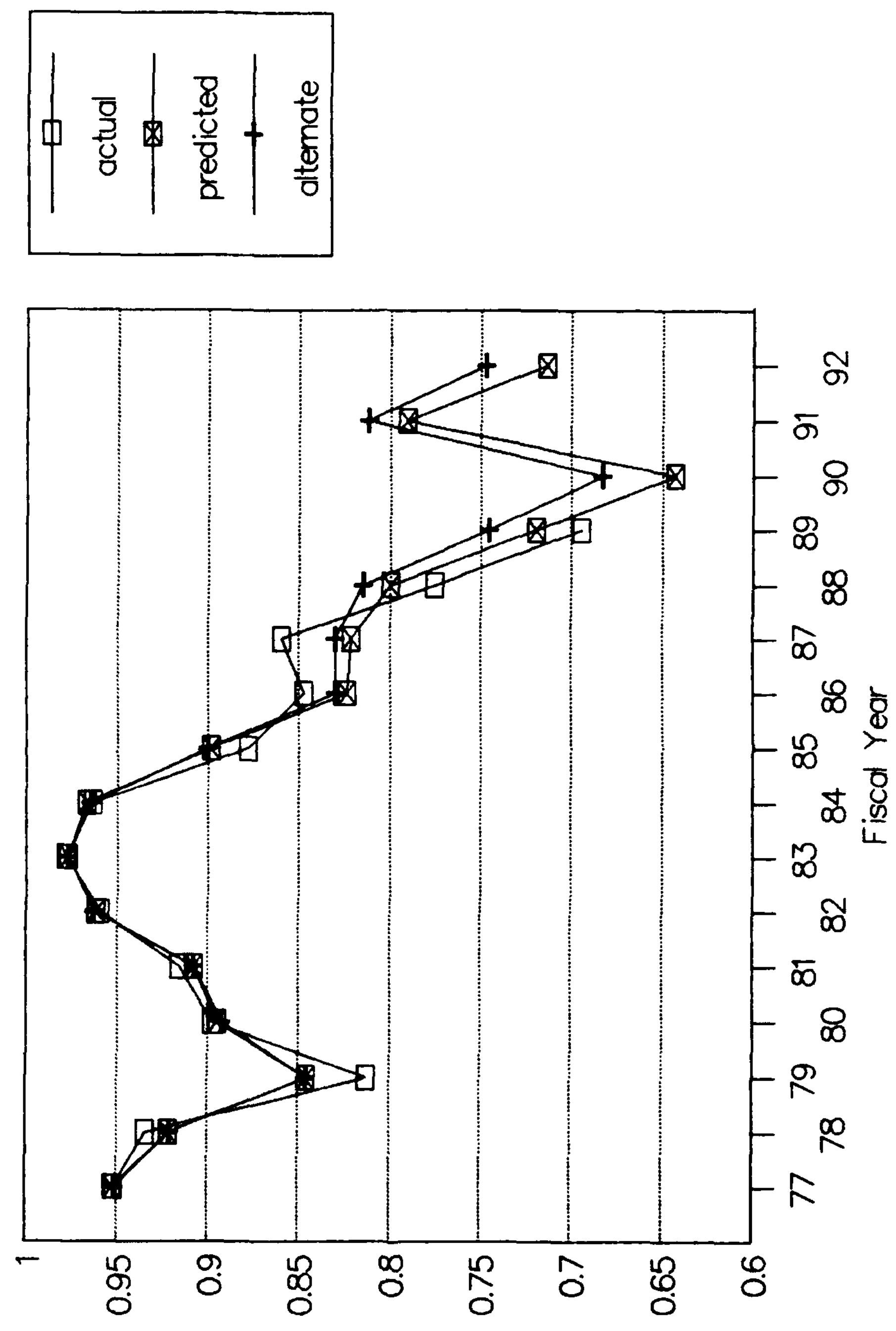




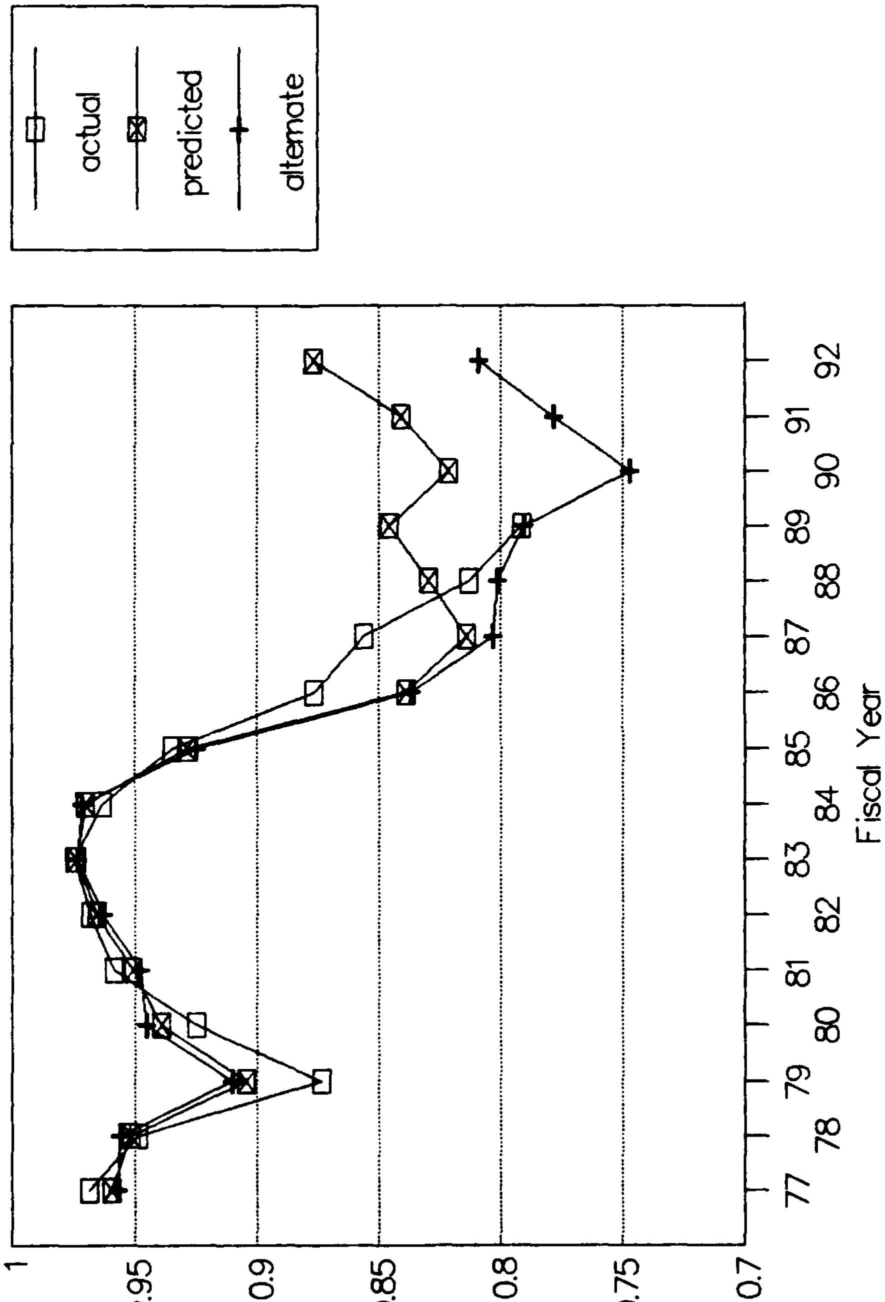
8YOS Retention Rates
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
Fiscal Year
actual
predicted
alternate



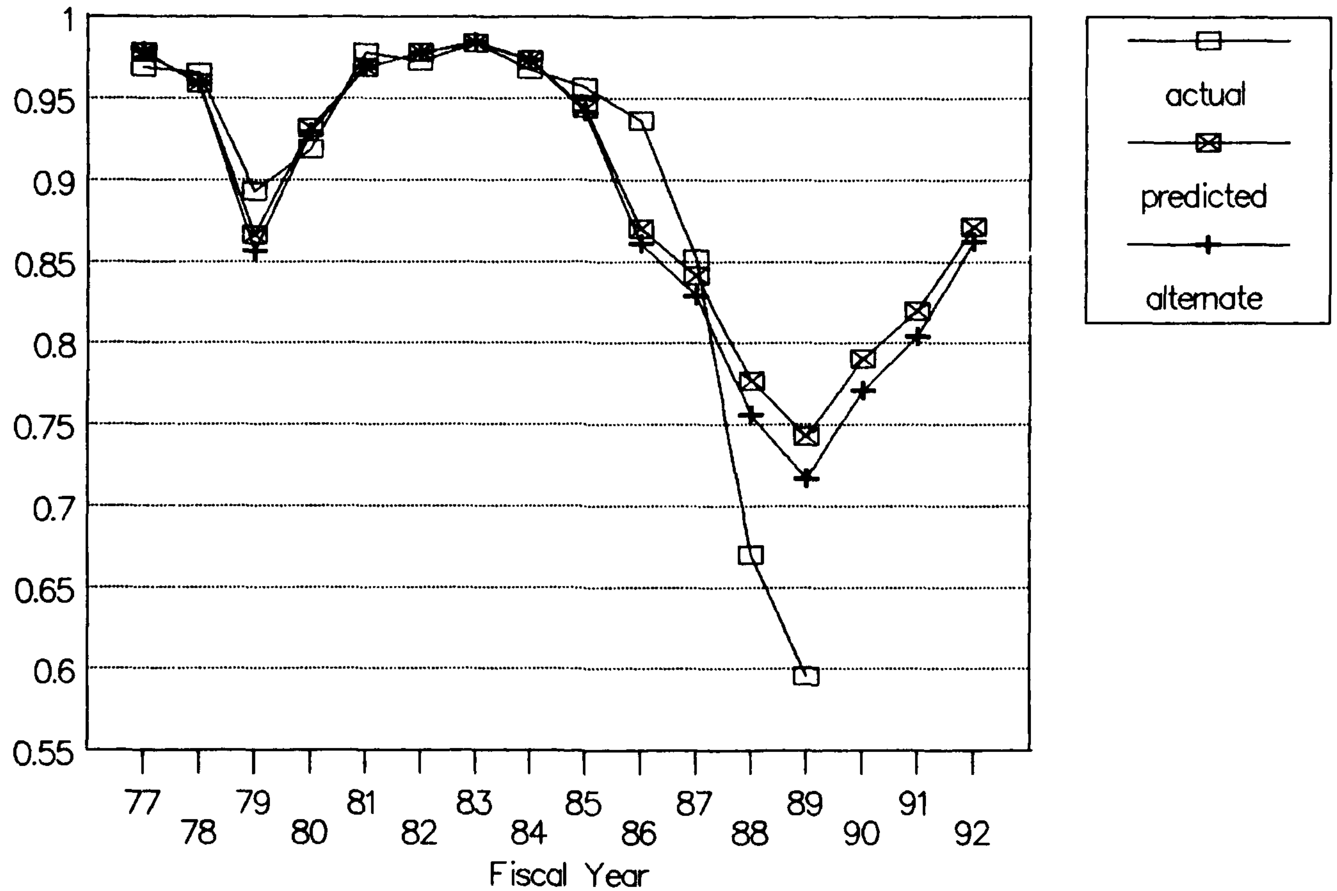
9YOS Retention Rates



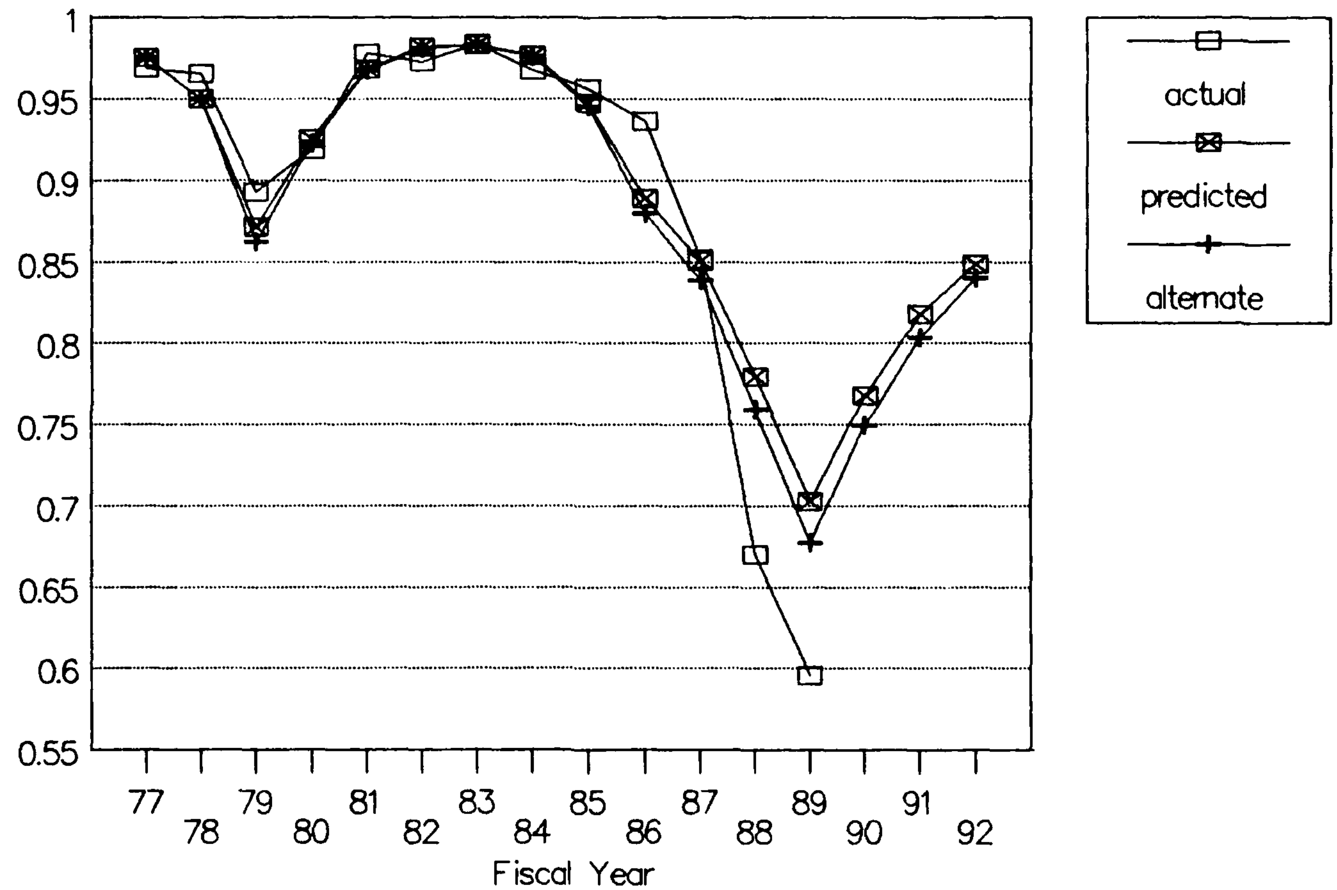
10YOS Retention Rates



11YOS Retention Rates

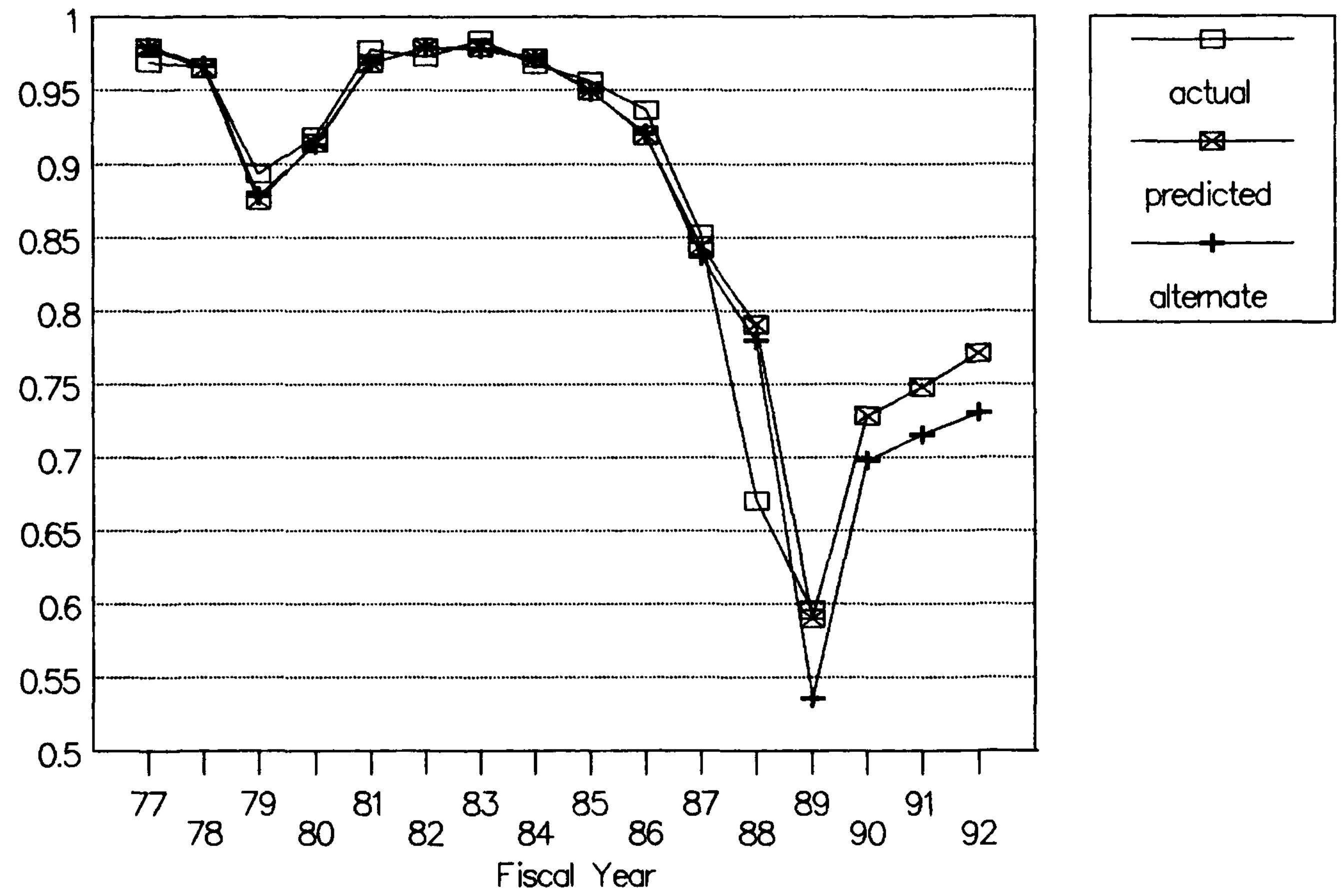


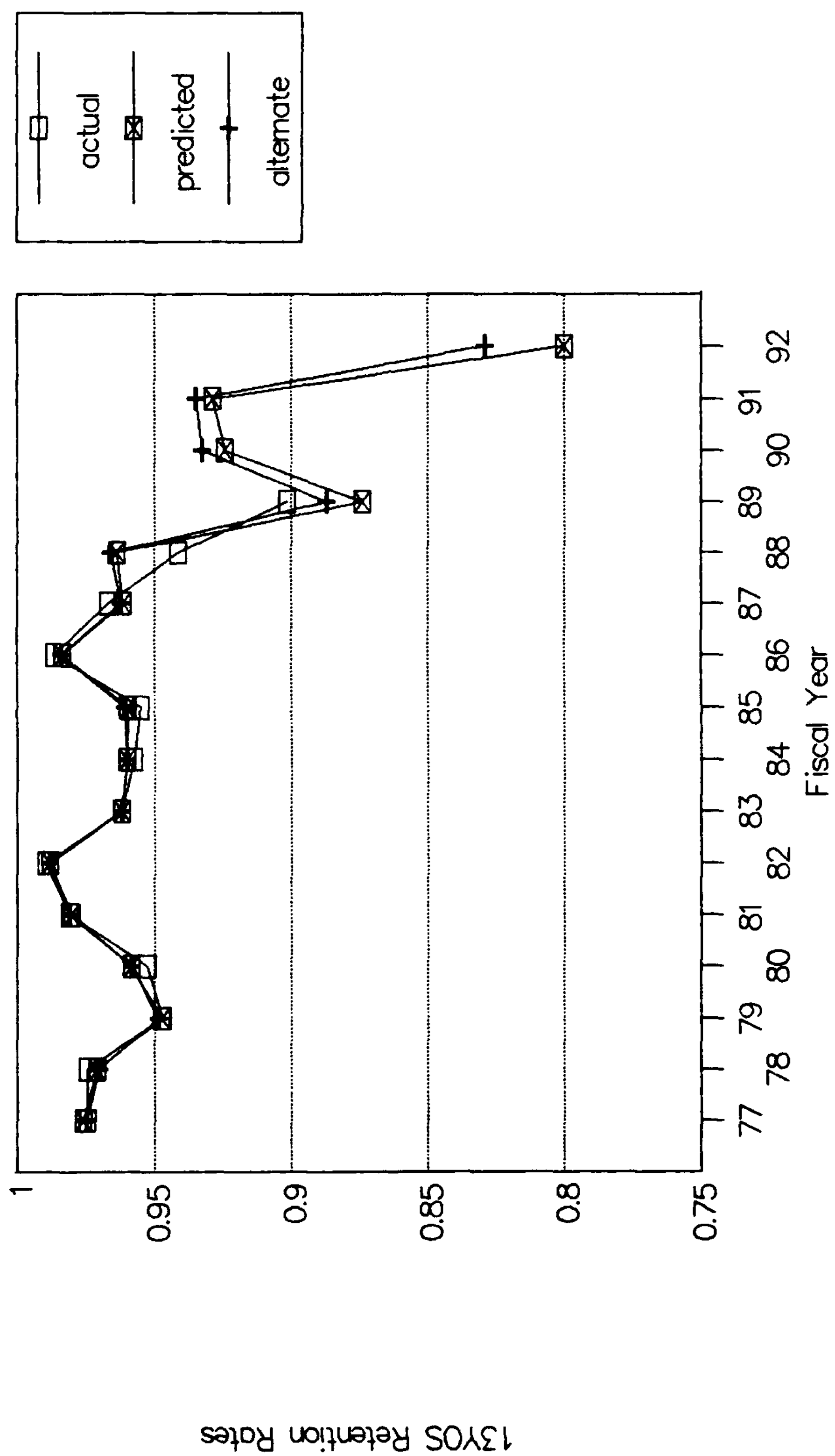
12YOS "A" Retention Rates

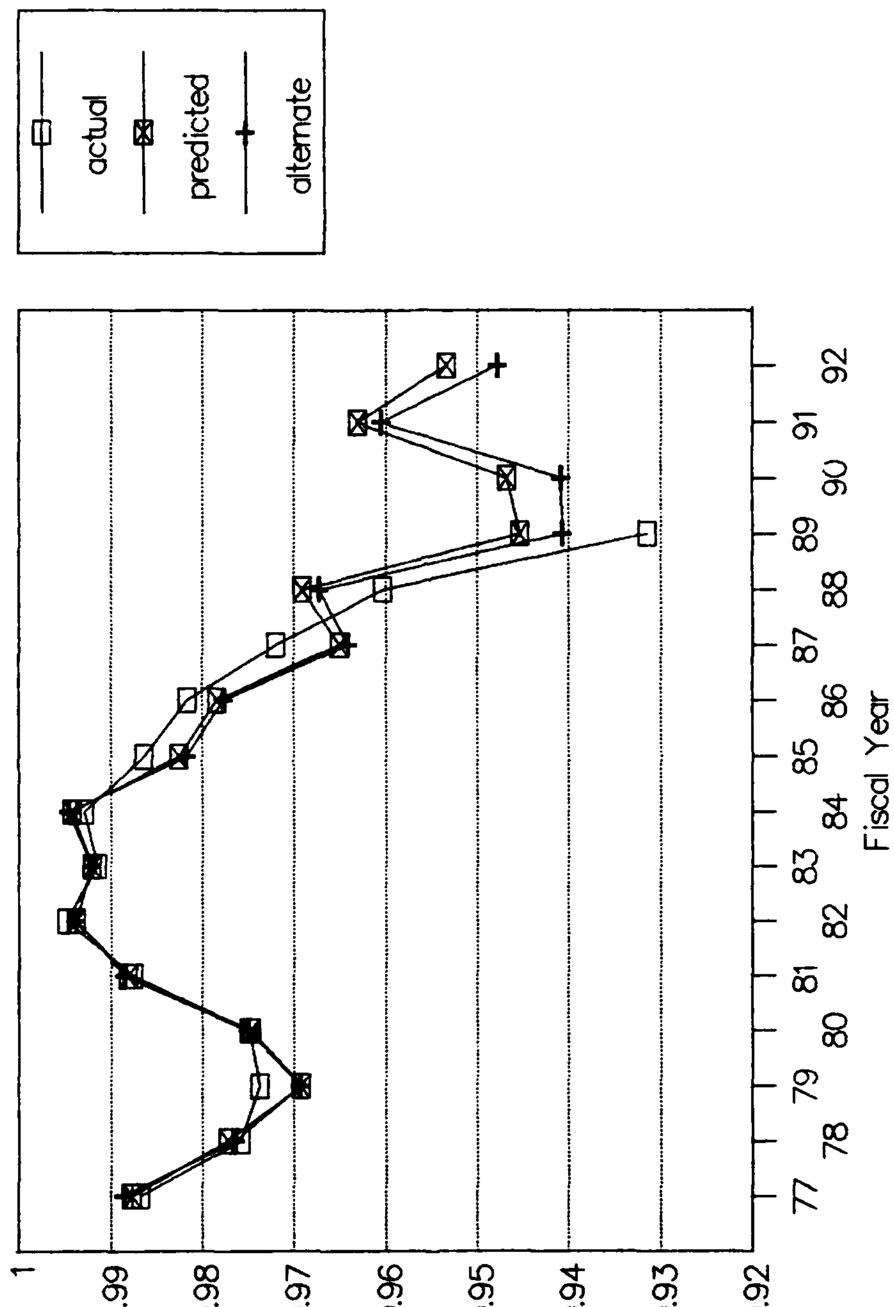


12YOS "B" Retention Rates

12YOS "C" Retention Rates




actual
predicted
alternate
1
0.95
0.9
0.85
0.8
0.75
77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92
Fiscal Year
13YOS Retention Rates



14YOS Retention Rates

Appendix I: Suggested Sources for Data

Published Sources

1. Bureau of the Census. *Current Industrial Reports, Series MA-37D.* Washington: Government Printing Office, July 1990.

2. Bureau of the Census. *Current Population Reports, Series P-25, No. 1057.* Washington: Government Printing Office, March, 1990.

3. Bureau of the Census. *Statistical Abstract of the United States: 1989.* Washington: Government Printing Office, 1989.

4. Bureau of Economic Analysis. *Survey of Current Business.* Washington: Government Printing Office, March, 1990.

5. Federal Aviation Administration. *FAA Aviation Forecasts -- Fiscal Years 1989-2000.* Washington: Government Printing Office, March, 1989.

Other Sources

1. Air Transport Association of America
   1709 New York Avenue, NW
   Washington, DC 20006-5206

2. Aerospace Industries Association of America
   1250 Eye Street, NW
   Washington, DC 20036

3. Aviation Resources, Inc.
   201 Smokerise Trace
   Peachtree City, GA 30269

4. Aviation Week and Space Technology
   Suite 1200
   1120 Vermont Avenue
   Washington, DC 20005

5. Boeing Company
   7755 E. Marginal Way, South
   Seattle, WA 98108

6. Future Aviation Professionals of America
4959 Massachussetts Boulevard
Atlanta, GA 30337-6607

7. McDonnell-Douglas Corporation
P.O. Box 516
St. Louis, MO 63166

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1. Brocklebank, John C. and David A. Dickey. *SAS System for Forecasting Time Series.* Cary NC: SAS Institute, Inc., 1986.

2. Bureau of Economic Analysis. *Business Statistics, 1961-88.* Washington DC: Government Printing Office, December 1989.

3. Chow, Gregory C. *Econometrics.* New York: McGraw-Hill, Inc., 1983.

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Vita

Major Bruce A. Guzowski is the youngest son of Major (USAF, Retired) [redacted] In 1973 he graduated from Aurora Central High School, Aurora, Colorado, and entered study at the Ohio State University on an Air Force ROTC scholarship. Commissioned in 1977, he was ordered to extended active duty in 1979 as a Base-level Accounting and Finance Officer at Bolling AFB. In 1981, his application to attend UPT was approved, and he subsequently earned his aeronautical rating at Columbus AFB. His operational assignments include piloting the CT-39A and C-12F at Andrews AFB, the C-12F at Osan AFB, and the C-141B at McGuire AFB. While at McGuire, he also became an Airlift Control Element (ALCE) Operations Officer. In 1989, he was assigned to the Air Force Institute of Technology's School of Systems and Logistics as a graduate student.

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13. ABSTRACT *(Maximum 200 words)* Personnel planners in various Air Force agencies use models, among other things, to aid them in forecasting pilot retention rates. This research effort attempted to forecast retention rates three years ahead with the use of regression analysis techniques. Such models can be of use to Air Force leaders to develop proactive policies and programs to combat poor retention forecasts.

Economically quantifiable variables were primarily used in the modeling effort. However, some year groups could not be adequately explained with the use of economic variables alone. The models for year groups eight, twelve, and thirteen used the retention rates of "peer groups" to assist in explaining their own retention rates.

All models were subjected to common internal tests associated with linear regression. External validity was verified by the use of a withheld data set. Forecasts were made for Fiscal Years 90, 91, and 92, using independent variable data from 1987, 1988, and 1989, respectively. All tests and forecasts were thoroughly documented.

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